Total Maximum Daily Load

for

Thompson River, Weldon River, and No Creek
Harrison and Livingston Counties

Section 303(d) Listing: *Escherichia coli* Bacteria

Submitted: June 24, 2022
Approved: August 30, 2022

WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for Thompson River, Weldon River, and No Creek
303(d) Listing: *Escherichia coli (E. coli)* Bacteria

Waterbody	TMDL Development Priority
Thompson River	High
Weldon River	High
No Creek	Low

Location: Harrison and Livingston counties

Location of watershed in Missouri

8-digit Hydrologic Unit Code (HUC):[1]
10280102 – Thompson River

12-digit HUC Subwatersheds
See Section 2

Water Body Identifications (WBIDs) and Hydrologic Class:[2]
WBID 549 – Class P – Thompson River
WBID 550 – Class P – No Creek
WBID 560 – Class P – Weldon River

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Drinking water supply (Thompson River, WBID 549 only)
Whole body contact recreation category B
Secondary contact recreation

Impaired Use:
Whole body contact recreation category B

Pollutant Identified on the 2020 303(d) List:
Escherichia coli (E. coli) (fecal indicator bacteria)

Identified Sources on the 2020 303(d) List:
Rural nonpoint sources

Length and Location of Impaired Segments:
Thompson River (WBID 549): 70.6 miles, from mouth to Township 67N, Range 26W
No Creek (WBID 550): 28.7 miles, from mouth to Township 62N, Range 23W
Weldon River (WBID 560): 43.4 miles, from mouth to Township 62N, Range 24W

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[1] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[2] For hydrologic classes see 10 CSR 20-7.031(1)(E). Class P streams maintain permanent flow even in drought periods.

[3] For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(F).

Table of Contents

Figures

Tables

1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing total maximum daily loads (TMDLs) to address elevated concentrations of *Escherichia coli* (*E. coli*) bacteria in Thompson River, Weldon River, and No Creek in Harrison to Livingston Counties. This TMDL report addresses three water quality limited segments that are on Missouri's 2020 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria concentration criterion.[4] These listings were approved by the U.S. Environmental Protection Agency (EPA) on November 30, 2020.[5] No Creek is also listed as impaired for Dissolved Oxygen on the 2020 303(d) List and will be addressed in a future TMDL.

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 7.031 consist of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacities for each water body are derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and are translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. In accordance with federal Clean Water Act section 303(d)(1)(C), a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies (40 CFR 130.7). The TMDL for each pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

2. Watershed Description

Thompson River, Weldon River, and No Creek are located in northcentral Missouri within the Thompson River subbasin, which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 10280102. The Thompson River subbasin is composed of 32, 12-digit HUC subwatersheds totaling 2,201 square miles (Table 1). Within this subbasin, the area of the Weldon River watershed is 155.8 square miles and the No Creek watershed is 110.6 square miles. Thompson River originates in Adair County, Iowa and flows south for 175.6 miles to the Grand River in Missouri. The extent of the Missouri portion of Thompson River (water body identification (WBID) 549) is 70.6 miles. Weldon River (WBID 550) and No Creek (WBID 560) are both tributaries of Thompson River. Weldon River originates in Decatur County, Iowa and flows south for 57.7 miles to Thompson River. The extent of the Missouri segment is 43.4 miles. No Creek is located entirely in Missouri and extends 28.7 miles northeast from the confluence at Thompson

[4] A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards, or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2).

[5] The Department maintains current and past 303(d) lists and corresponding assessment worksheets online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters.

River. Within the Thompson subbasin, TMDLs have previously been developed for three water bodies. EPA approved TMDLs in 2010 for Muddy Creek (WBID 557) and a tributary to Hickory Creek (WBID 589) that address unknown impairments. EPA also established a TMDL for Honey Creek (WBID 554) in 2006 to address sediment. These other approved or established TMDLs are available on the Department's website at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Table 1. 12-digit HUC subwatersheds in Thompson River Watershed

12-digit HUCs	Subwatershed Name
10280102-0602	Indian Creek
10280102-0603	Jefferies Creek-Thompson River
10280102-0604	Coal Creek-Thompson River
10280102-0605	Panther Creek
10280102-0606	Brushy Creek-Thompson River
10280102-0704	Brush Creek-Little River
10280102-0806	Lick Branch-Weldon River
10280102-0901	Big Branch-Weldon River
10280102-0902	West Muddy Creek
10280102-0903	Wildcat Creek-Weldon River
10280102-0904	Middle Creek-Weldon River
10280102-1001	Sandy Creek
10280102-1002	Trail Creek
10280102-1003	Martin Creek-Thompson River
10280102-1004	Cat Creek-Thompson River
10280102-1005	Fox Creek-Sugar Creek
10280102-1006	Raccoon Creek
10280102-1007	Sugar Creek
10280102-1008	Lost Creek-Thompson River
10280102-1101	Upper Muddy Creek
10280102-1102	Middle Muddy Creek
10280102-1103	Lower Muddy Creek
10280102-1201	East and West Forks Honey Creek
10280102-1202	Upper Honey Creek
10280102-1203	Lower Honey Creek
10280102-1301	Headwaters No Creek
10280102-1302	Crooked Creek
10280102-1303	No Creek
10280102-1401	Hickory Creek
10280102-1402	Gees Creek
10280102-1403	Wolf Creek-Thompson River
10280102-1404	Thompson River

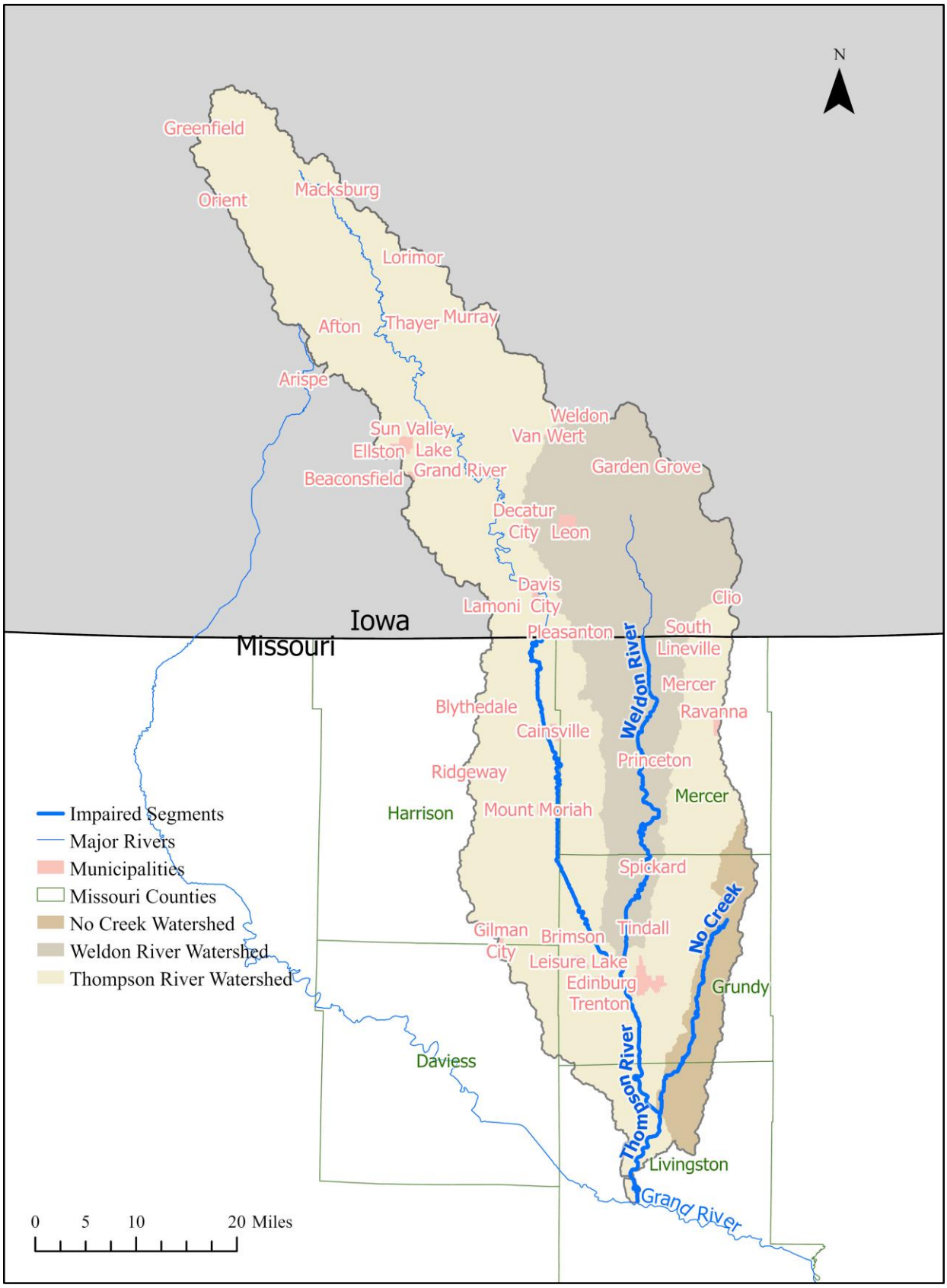

Figure 1. Thompson River, Weldon River, and No Creek watersheds

2.1 Geology, Physiography, and Soils

Thompson River, Weldon River, and No Creek are located within the Grand/Chariton ecological drainage unit, which consists of northcentral Missouri and southcentral Iowa (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). Within the Grand/Chariton ecological drainage unit, the majority of Thompson River watershed is within the Loess Flats and Till Plains and fifteen percent of the watershed is within the Rolling Loess Prairies EPA Level IV ecoregion (ecological subsection). Both the Weldon River and the No Creek watersheds are within the Loess and Till Plains Level IV ecoregion. Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H).

Thompson River originates in the Rolling Loess Prairies ecoregion. This ecoregion is defined by thin loess deposits (less than 25 feet) and open low hills. Eighty-five percent of Thompson River watershed, and all of Weldon River and No Creek watersheds, are situated within the Loess and Till Plains Level IV. The topography in this region varies from flat to moderately hilly and tends to contain deeper loess deposits than the rolling Loess Prairies ecoregion, (MoRAP 2005).

Soils are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.[6] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Figure 2 shows the distribution of hydrologic soil groups and karst features in the Thompson River, Weldon River, and No Creek watersheds. Geographic Information System (GIS) analysis of the Thompson River watershed identified two springs and one stream that receives water from the subsurface (gaining stream). Table 2 provides a summary of the hydrologic soil groups by area in square miles and relative percent.

[6] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

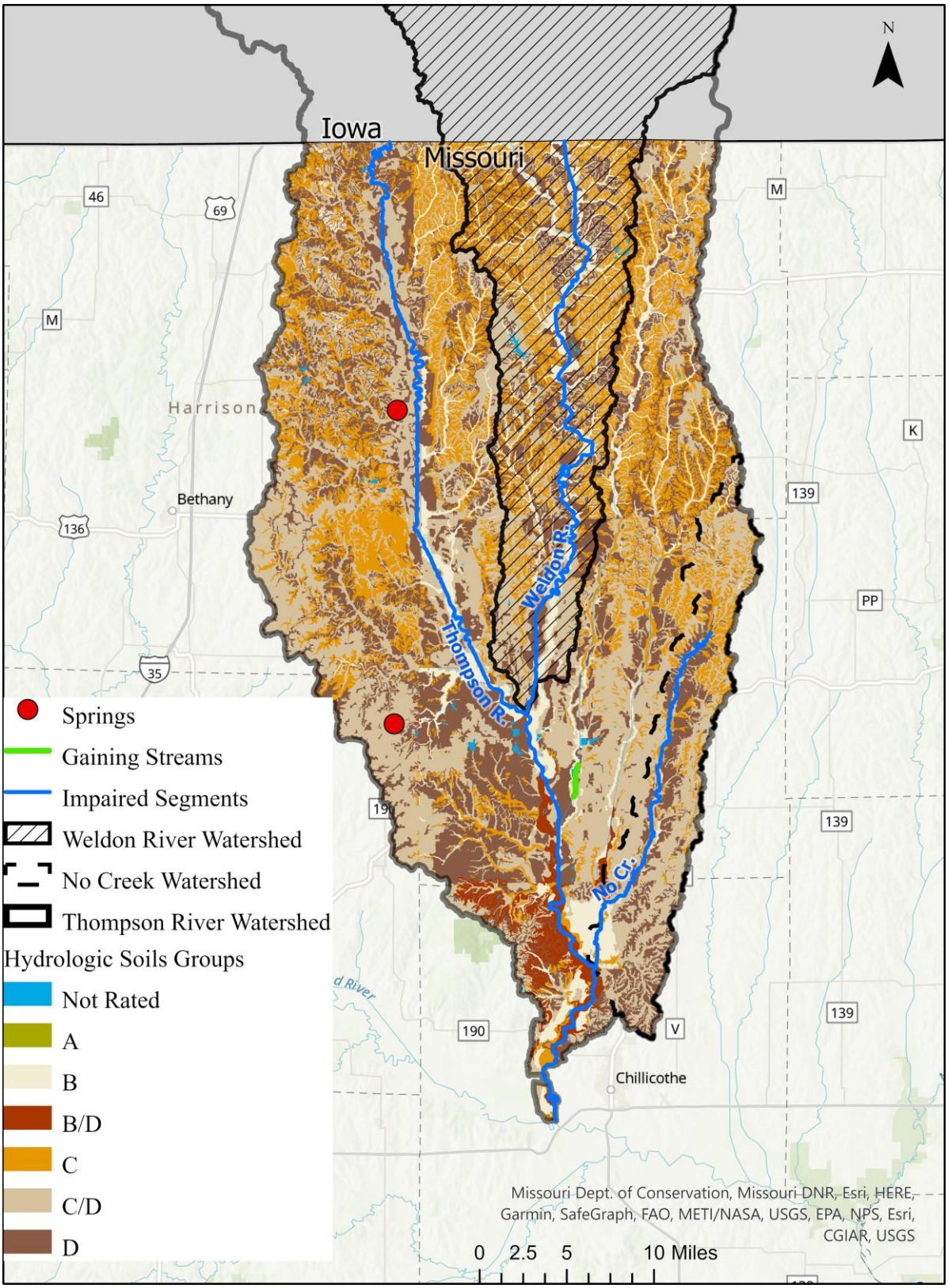

Figure 2. Hydrologic Soil Groups and Karst Features in the Thompson River, Weldon River, and No Creek Watersheds

Table 2. Hydrologic Soil Groups in the Thompson River, Weldon River, and No Creek Watersheds (NRCS 2020)

Hydrologic Soil Group	Area in the Watershed	
	Square Miles	Percent
Thompson River		
A	0.75	0.07%
B	82.95	7.50%
B/D	23.27	2.10%
C	258.92	23.41%
C/D	432.00	39.05%
D	297.31	26.88%
Open Water	11.05	1.00%
Total	1,106.24	100.00%
Weldon River		
A	0.66	0.31%
B	27.39	12.71%
B/D	0.00	0.00%
C	63.40	29.42%
C/D	66.57	30.89%
D	54.32	25.20%
Open Water	3.20	1.48%
Total	215.54	100.00%
No Creek		
Open Water	0.11	0.10%
B	4.42	4.00%
B/D	0.52	0.47%
C	18.65	16.87%
C/D	60.36	54.58%
D	26.54	24.00%
Total	110.60	100.00%

2.2 Climate

The most recent climate data from a weather station in close proximity to the Thompson River watershed were measured at the Creston 2 SW, Iowa weather station (USC00131962) in Union County, Iowa. The climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA 2021). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. Table 3 presents the 30-year monthly climate normals from the Creston weather station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 3. 30-year Monthly Climate Normals at Creston, Iowa

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	in	ºF	ºF
January	1.25	18.3	36.6
February	1.6	22.2	42.3
March	2.8	32.6	54.1
April	3.84	42.9	65.6
May	5.42	53.5	74.8
June	5.29	63.5	83.5
July	4.1	67.3	87.8
August	4.76	65.2	86
September	3.84	55.9	78.6
October	3.25	44.1	66.8
November	2.43	32.4	53
December	1.7	23.1	41.2
	Total	**Average**	**Average**
	40.28	43.4	64.2

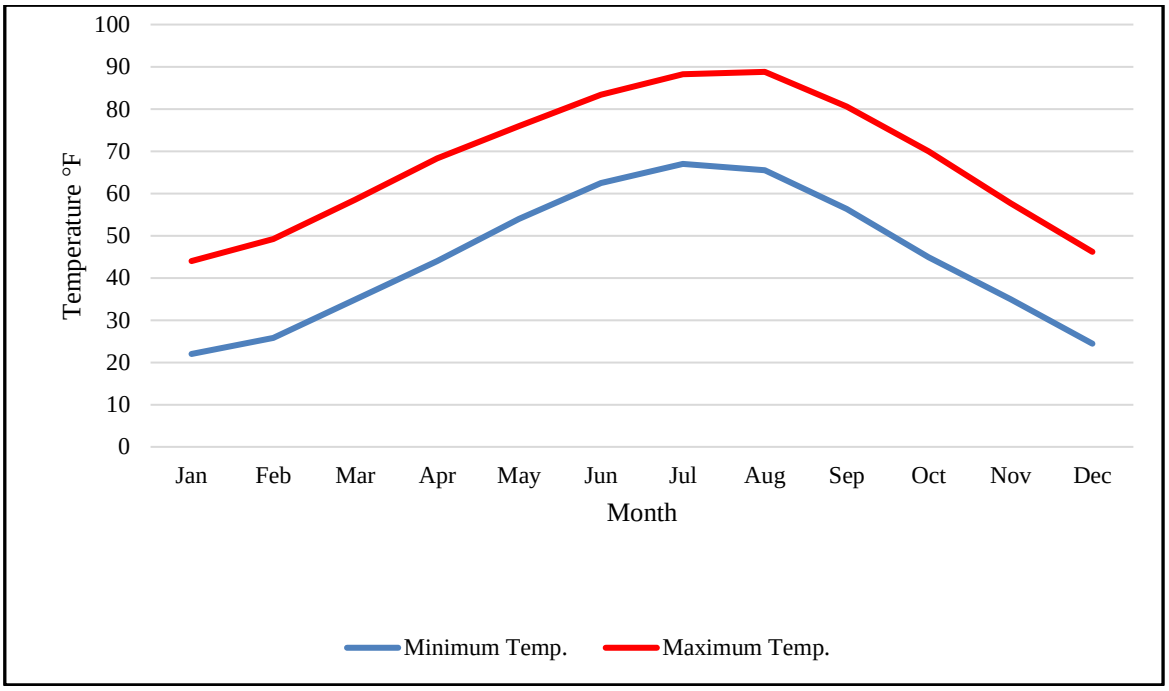

Figure 3. Monthly Minimum and Maximum Temperature Normals – Creston, Iowa

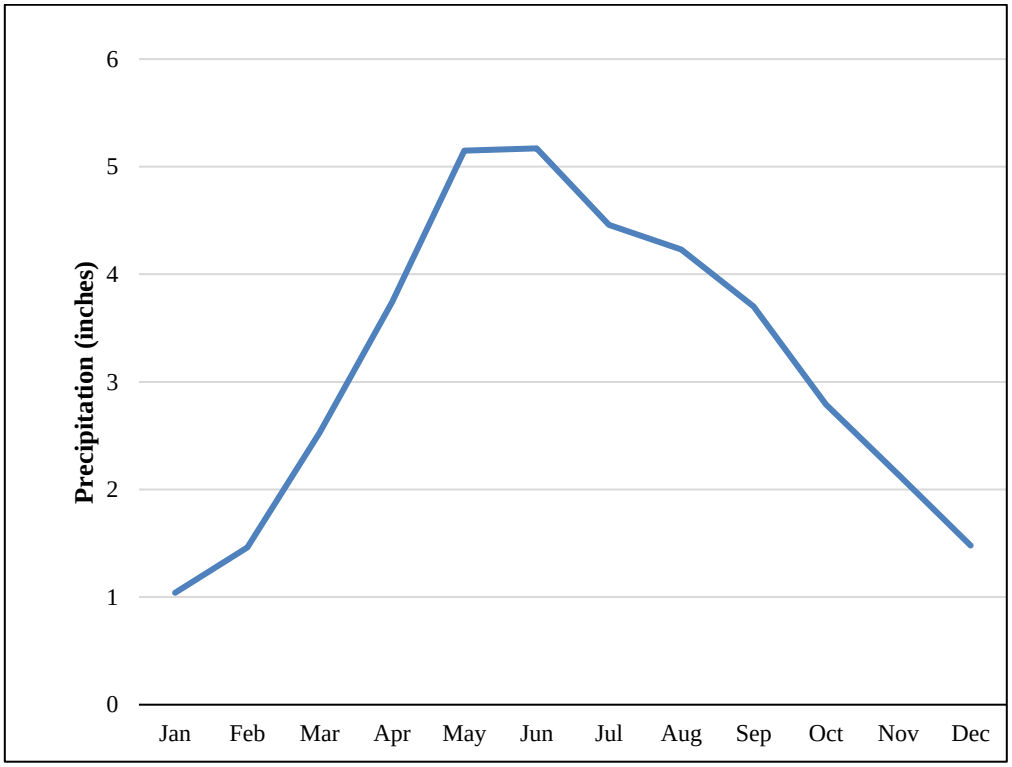

Figure 4. Monthly Precipitation Normals – Creston, Iowa

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2010 census and can be localized using census block data (U.S. Census Bureau 2010). Population estimates for the Thompson River, Weldon River, and No Creek watersheds were derived using GIS software by overlaying the watershed boundaries over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within a watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas were overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population.

As shown in Table 4, the populations in the Thompson River, Weldon River, and No Creek watersheds have stayed relatively the same since 1990. At the time of the 2010 census, the U.S. Census Bureau did not designate any urban areas in these watersheds. Urban area designation is one criterion used to determine whether urban stormwater discharges are subject to municipal separate storm sewer system (MS4) permit regulations. There are no regulated MS4s in the Thompson River, Weldon River, and No Creek watersheds.

Table 4. Population data for Thompson River, Weldon River, and No Creek watersheds

Watershed			Thompson River Watershed	Weldon River Watershed	No Creek Watershed
Missouri Population	Municipal	1990	9,324	1,433	0
		2000	9,741	1,464	0
		2010	9,674	1,525	0
	Rural	1990	7,709	1,416	1,102
		2000	7,359	1,424	1,069
		2010	7,150	1,390	955
	Total	1990	17,033	2,849	1,102
		2000	17,100	2,888	1,069
		2010	16,824	2,915	955
Total Watershed Population (w/Iowa)	Municipal	2010	20,366	5,870	0
	Rural		15,634	1,773	955
	Total		36,000	7,643	955

Demographic data from the U.S. Census Bureau is included in EPA's web-based EJSCREEN tool and may be used to identify areas in the watershed with potential environmental justice concerns. The EJSCREEN tool is available at https://www.epa.gov/ejscreen. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities determined to have environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. One example of financial assistance the Department offers that may be available to areas having environmental justice concerns is Section 319 grant funding to address nonpoint sources. The Department evaluates 319 grants on a number of criteria, but gives higher priority for selection to proposed projects in disadvantaged communities. Additional grant

and financial resource information is available on EPA's environmental justice website at www.epa.gov/environmentaljustice.

The EJSCREEN tool integrates 11 environmental pollution, 6 demographic indicators, and a demographic index based on percent low income and percent minority. EJSCREEN results highlight places that may be candidates for further review, analysis, or outreach to support EPA's environmental justice work. EJSCREEN is currently based on 2010 census data and indicator outputs may change when 2020 census data becomes available. Information on the development, limitations, and intended uses of EJSCREEN, as well as access to the mapping tool can be found at the EJSCREEN website.

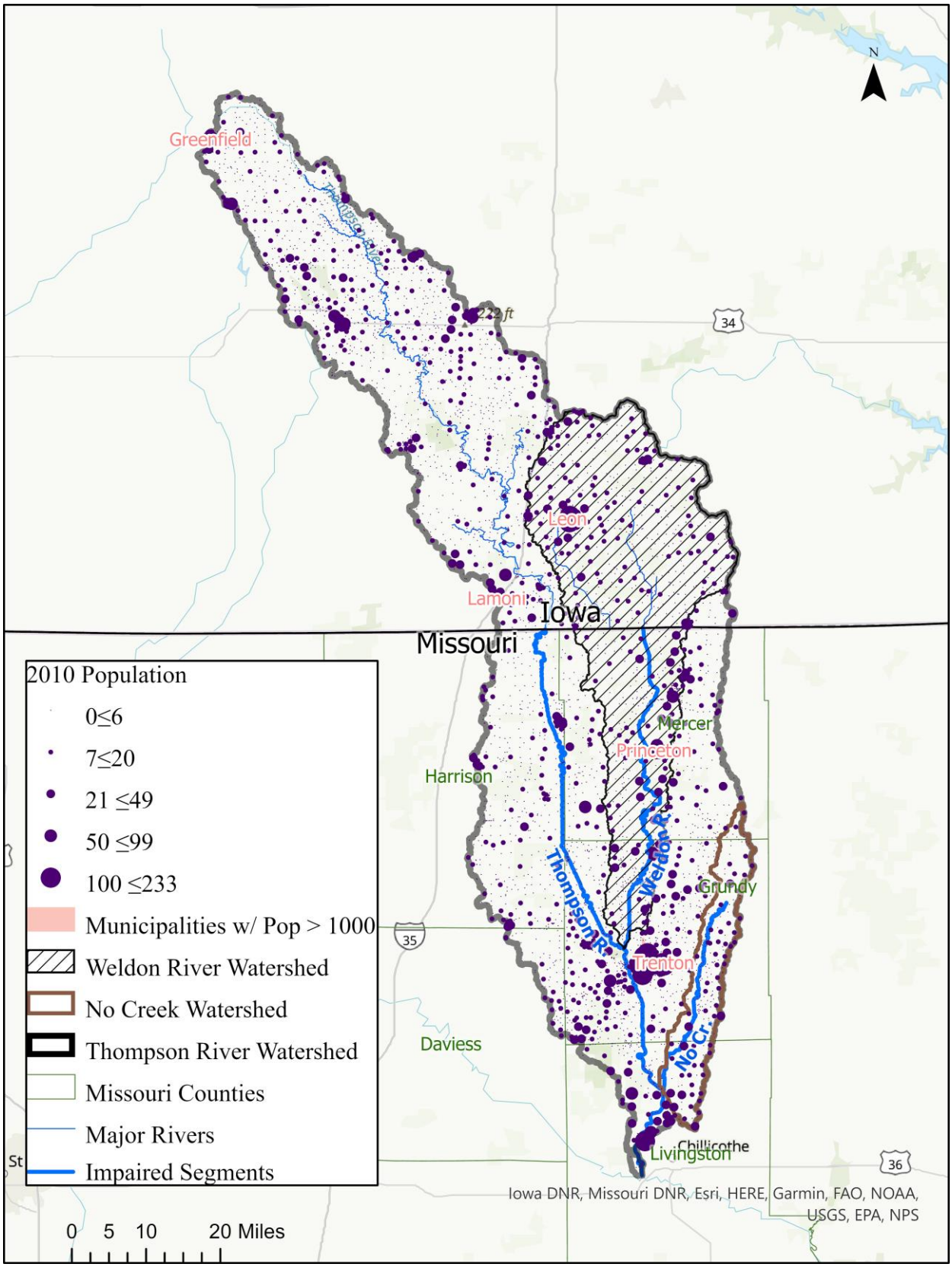

Figure 5. 2010 Population in the Thompson River, Weldon River, and No Creek Watersheds

2.4 Land Cover

A land cover analysis was completed using the 2019 National Land Cover Database published by USGS (Homer et al. 2015). Land cover types present in the Thompson River, Weldon River, and No Creek watersheds are summarized in Tables 5, 6, and 7. Figure 6 depicts the distribution of the land cover types throughout the watershed. Agricultural land (cultivated crops, hay/pasture) account for 70 percent of the Thompson River watershed.

Table 5. Land Cover in the Thompson River Watershed

Land Cover Type	Total Watershed		Missouri Only	
	Area (Square Miles)	Percent	Area (Square Miles)	Percent
Developed, High Intensity	0.848	0.04%	0.487	0.04%
Developed, Medium Intensity	5.464	0.25%	2.349	0.21%
Developed, Low Intensity	41.283	1.88%	17.209	1.56%
Developed, Open Space	46.112	2.09%	27.313	2.47%
Barren	2.246	0.10%	1.702	0.15%
Cultivated Crops	706.105	32.08%	343.519	31.06%
Hay/Pasture	896.857	40.75%	435.830	39.40%
Shrub/Herbaceous	13.369	0.61%	6.856	0.62%
Forest	431.688	19.61%	235.146	21.26%
Wetlands	40.187	1.83%	28.085	2.54%
Open Water	16.898	0.77%	7.666	0.69%
Totals	2,201.057	100.00%	1,106.163	100.00%

Table 6. Land Cover in the Weldon River Watershed

Land Type	Total Watershed		Missouri Only	
	Area (Square Miles)	Percent	Area (Square Miles)	Percent
Developed, High Intensity	0.202	0.04%	0.089	0.04%
Developed, Medium Intensity	1.252	0.22%	0.46	0.21%
Developed, Low Intensity	11.309	2.00%	3.494	1.62%
Developed, Open Space	11.127	1.96%	5.744	2.67%
Barren	0.593	0.10%	0.46	0.21%
Cultivated Crops	140.418	24.78%	50.178	23.28%
Hay/Pasture	251.675	44.42%	86.79	40.27%
Shrub/Herbaceous	4.588	0.81%	1.591	0.74%
Forest	132.154	23.32%	59.225	27.48%
Wetlands	9.112	1.61%	5.791	2.69%
Open Water	4.197	0.74%	1.68	0.78%

Totals	566.626	100.00%	215.503	100.00%

Table 7. Land Cover in the No Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.013	0.01%
Developed, Medium Intensity	0.137	0.12%
Developed, Low Intensity	1.764	1.60%
Developed, Open Space	2.505	2.27%
Barren Land	0.016	0.01%
Cultivated Crops	43.338	39.21%
Hay/Pasture	46.558	42.13%
Shrub and Herbaceous	0.415	0.38%
Forest	10.900	9.86%
Wetlands	4.580	4.14%
Open Water	0.295	0.27%
Totals	110.522	100.00%

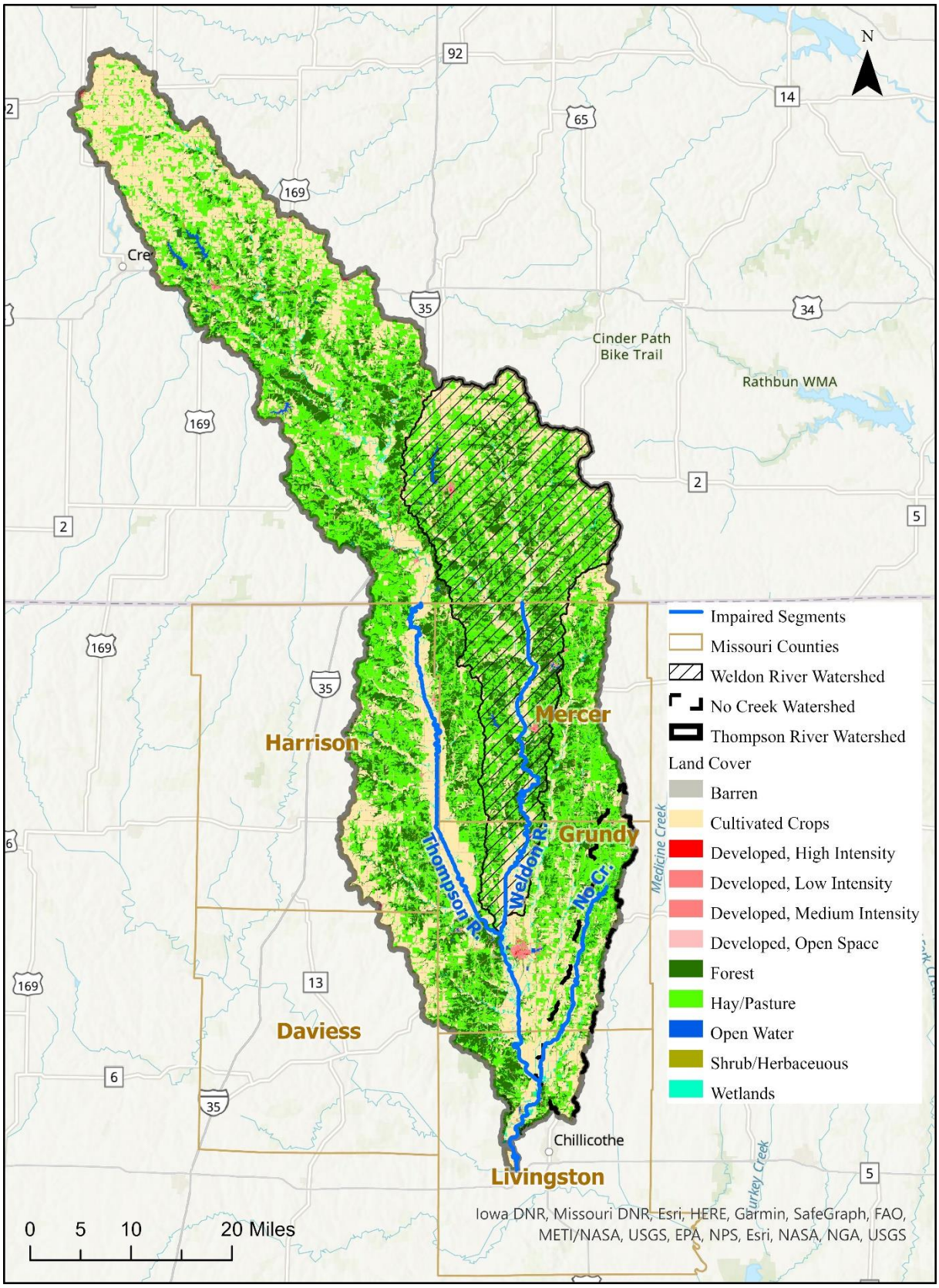

Figure 6. Land Cover in Thompson River, Weldon River, and No Creek Watersheds

3. Applicable Water Quality Standards

TMDLs identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10(b), Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.[7]

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(C) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses of Thompson River, Weldon River, and No Creek:

- Irrigation;
- Drinking water (WBID 549 only)
- Livestock and wildlife protection;
- Human health protection;
- Warm water habitat (aquatic life);
- Whole body contact recreation category B; and
- Secondary contact recreation.

The whole body contact recreation category B designated uses of Thompson River, Weldon River, and No Creek are impaired due to high *E. coli* bacteria concentrations. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(F)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(F)2.A.(I)). Whole body contact category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(F)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(F)2.B.). The secondary contact recreation uses are not impaired in Thompson River, Weldon River, nor in No Creek.

[7] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. For whole body contact recreation category B waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 206 colony forming units (cfu) per 100 milliliters (mL) of water. This criterion is also protective of secondary contact recreational uses.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulations related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Thompson River, Weldon River, No Creek are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In accordance with Missouri's 2020 Listing Methodology Document, the whole body contact recreation category B designated uses for Thompson River, Weldon River, and No Creek are impaired because

the geometric means of *E. coli* samples collected during the recreational season from April 1 to October 31 were greater than 206 cfu/100 mL in the most recent three years having available data with five or more samples.[8] Sufficient data consistent with the assessment methodology are available to support these listings as summarized in Table 8 and Figure 7. As shown, in years with five or more samples *E. coli* concentrations exceeded the geometric mean of 206 cfu/100 mL in Thompson River in 2016-2019, No Creek in 2016-2020, and Weldon River in 2019. Segments of Thompson and Weldon River are identified as impaired by E. coli on Iowa's 2020 303(d) List.

Individual *E. coli* measurements are provided in Appendix A to illustrate the nature of the impairment but were not used in the calculation of TMDL loading capacities or allocations. Individual measurements may be used to estimate pollutant reduction targets, to target implementation activities, and to select appropriate best management practices. Reduction targets for Thompson River, Weldon River, and No Creek are presented in a supplemental TMDL implementation strategies document available online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls

Table 8. Summary of Recreational Season *E. coli* Data for the Impaired Water Bodies[9]

Water Body	Recreational Season	Number of Samples	Min (cfu/100 mL)	Max (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
Thompson River	2020	4	23	18,000	386.25
	2019	5	100	20,000	635.19
	2018	11	31	5,000	453.59
	2017	11	52	20,000	389.54
	2016	11	52	6,500	722.70
No Creek	2020	5	180	3,200	679.13
	2019	7	150	2,000	271.70
	2018	7	46	13,000	325.22
	2017	7	150	2,500	607.15
	2016	7	180	17,000	700.64
Weldon River	2020	4	60	32,000	455.39
	2019	5	16	50,000	686.36
	2018	4	33	12,000	381.27
	2017	4	29	450	153.01
	2016	4	120	4,400	599.72
	2015	4	110	37,000	3,170.93
	2014	4	340	5,600	730.55
	2013	5	58	510	131.86

[8] Listing Methodology documents are available online at dnr.mo.gov/document/methodology-development-2020-section-303d-list-missouri

[9] *E. coli* data may be reported in units of most probably number (MPN) or colony forming units (cfu) depending upon the analysis method used. Data reported as cfu is an actual count of bacteria colonies, whereas MPN is a statistical approximation. Although differences may exist, they are often used interchangeably. For purposes of this TMDL, all *E. coli* data are presented in units of cfu regardless of the methodology used for simplicity and in order to maintain consistency with Missouri Water Quality Standards.

Water Body	Recreational Season	Number of Samples	Min (cfu/100 mL)	Max (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
	2012	4	92	1,800	292.17
	2011	4	25	30,000	236.26
	2010	4	11	15,000	262.10
	2009	4	34	500	187.76
	2008	3	670	7,200	1,744.21
	2007	5	10	280	80.66

* Although geometric means are presented for all years of available data, only years with a minimum of five samples were used for assessment purposes.

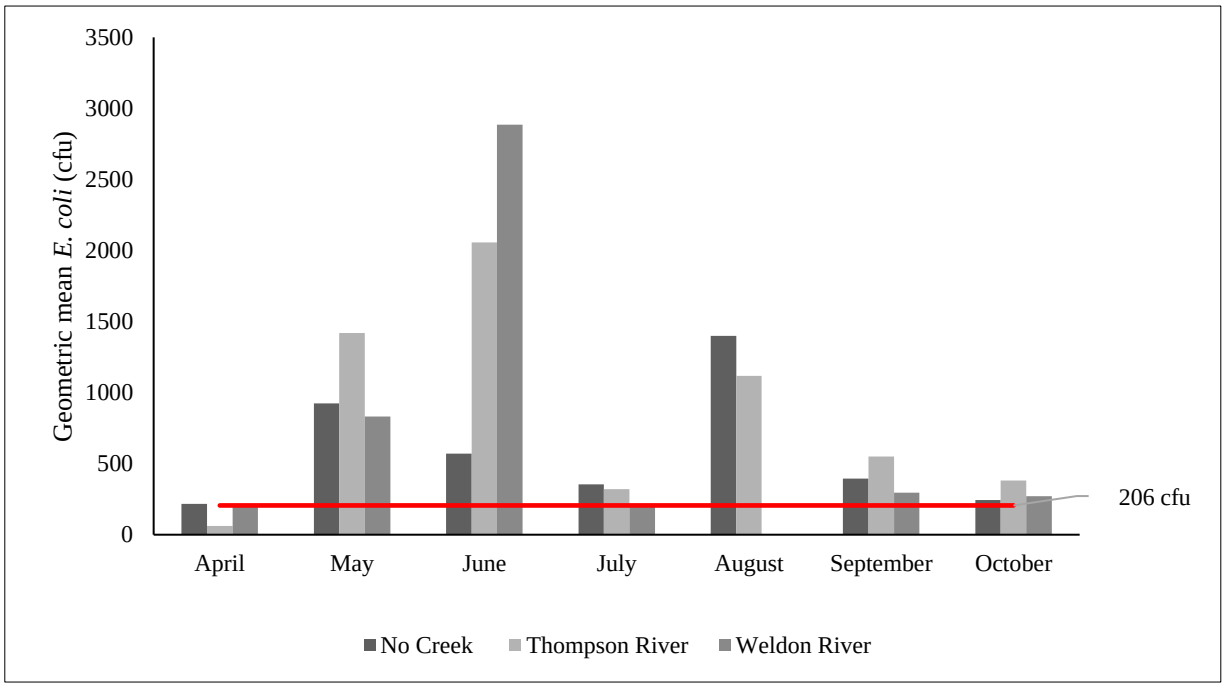

Figure 7. Geometric Means of *E. coli* Data by Month (Includes years with <5 samples)

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to the elevated *E. coli* concentrations in the impaired water bodies. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading to Thompson River, Weldon River, and No Creek. Sources of bacteria loading are identified and quantified to the extent that information is available.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[10] A point source is defined as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural storm water discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), MS4s, and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. The locations of permitted point sources in the Thompson River, Weldon River, and No Creek watersheds are presented in Figure 8.[11] Facilities and their expected contributions to the impaired streams are described individually in the following sections.

[10] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain an NPDES permit. Issued and proposed operating permits are available online at dnr.mo.gov/env/wpp/permits/index.html.

[11] Each marker on the map represents an outfall. There may be multiple outfalls per facility.

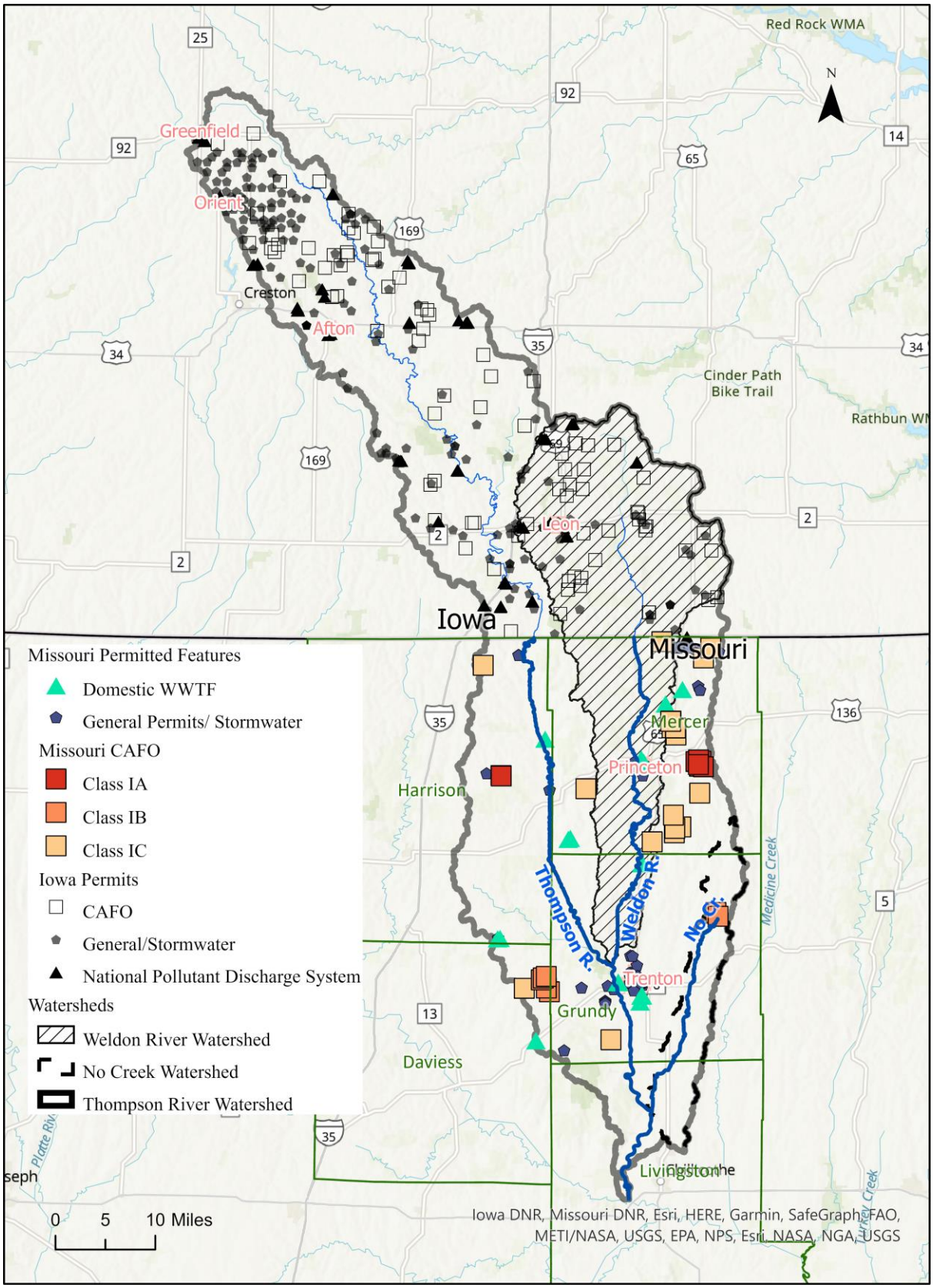

Figure 8. Permitted Features and Outfalls in the Thompson River, Weldon River, and No Creek Watersheds

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). Facilities equipped with disinfection technologies discharge *E. coli* at very low concentrations and should not cause or contribute to bacteria impairments.

The cities of Trenton, Mercer, Gilman, Princeton, Spickard, Cainsville, and Twin Lakes operate municipal domestic wastewater treatment facilities (WWTF) in the Thompson watershed (Table 9). Twin Lakes, Princeton, and Spickard are also located in the Weldon watershed. There are no wastewater treatment facilities within No Creek watershed. There are no privately owned domestic wastewater treatment facilities in any of the three watersheds. Gilman City WWTF was under enforcement in 2014 for failing to upgrade to meet effluent limits, but returned back into compliance as of February 2021 after upgrading their facility. The facility upgraded to an irrigation system to land apply wastewater and does not discharge directly to surface waters. The land application field is approximately 13 miles upstream from Thompson River. The permits for these types of facilities require setbacks from streams and other conditions to minimize bacteria loading to surface waters. When all permit requirements are met, this municipal WWTF is not exptected to contribute to the water quality impairments of Thompson River. The rest of the WWTF have permits that contain *E. coli* limits of 206 cfu/100 mL. Cainsville and Spickard WWTF have a schedule of compliance to meet *E. coli* limits by July 2025 and June 2022, respectively. The other four facilities have met their *E. coli* limits in the last five years of the time of this writing. Until all *E. coli* limits are met, these facilities are potentially significant sources of *E. coli* loading to the Thompson and Weldon River.

Table 9. Domestic Wastewater Treatment Facilities in the Thompson, Weldon, and No Creek Watersheds

Permit Number	Facility Name	Design Flow (mgd)	General Treatment Type	Permit Expiration[12]
MO0122467	Cainsville WWTF	0.050	Lagoon	6/30/2024
MO0098663	Gilman City WWTF	0.00	Storage Basin and Land Application	3/31/2024
MO0056057	Mercer WWTF	0.048	Lagoon	12/31/2023
MO0028762	Princeton WWTF	.191	Lagoon	12/31/2023
MO0113026	Spickard WWTF	0.04	Lagoon	12/31/2023
MO0039748	Trenton Municipal Utilities WWTP	3	Mechanical Plant	6/30/2024
MO0129216	Twin Lakes WWTF	0.14	Lagoon	9/30/2023

Potential bacteria loading from domestic wastewater treatment facilities may also occur from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases commercial and industrial wastewater, to the domestic wastewater treatment facility. Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater, but are typically not designed to collect large amounts of runoff from precipitation events.

[12] When an NPDES permit expires, the permittee remains bound by the conditions of that expired permit until either the permit is terminated or a new permit is issued.

Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows can be caused by high volume precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system, but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

Four facilities reported sanitary sewer overflows in the last five years. The Mercer WWTF reported one in 2017. Princeton WWTF reported two in 2017, two in 2018, five in 2019, one in 2020, and one in 2021. Spickard WWTF reported three in 2019 and one in 2021. Trenton Municipal Utilities WWTF reported one in 2016, three in 2017, and two in 2018. Sanitary sewer overflows are not expected to be a significant contributor of *E. coli* to the Thompson or Weldon River because unintentional discharge of untreated domestic wastewater in this watershed is rare and temporary in nature. Missouri State Operating permits and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their facility's collection systems. This is implemented through a special permit condition or schedule of compliance.

5.1.2 Industrial and Commercial Facilities

Industrial and commercial facilities discharge process water used or generated during mining, manufacturing, or food processing activities, and may also include landfills. Mining and manufacturing facilities are not expected to cause or contribute to bacteria impairments. Food processing wastewater may contain bacteria. There are no site specific permitted industrial or commercial facility in the Thompson River watershed, but there are four general permitted facilities and are listed on Table 11. Two of these facilities are within the Weldon River watershed. Princeton Water Treatment Plant and Trenton Water Treatment Plant hold a general permit for water treatment plant settling basin and does not allow discharge of plant sludge to surface water. Additionally there are two facilities, Yoder Sausage Kitchen and Sunrise Meats LLC, that hold general permits for land application of food processing wastewater. These facilities are not authorized to discharge to surface waters. If a facility meets all land application permit requirements, it will not be a significant contributor of *E. coli* to the Thompson and Weldon River watersheds. General permits are further discussed in Section 5.1.5.

5.1.3 Concentrated Animal Feeding Operations

Animal waste generated from CAFOs can be a source of bacteria to water bodies (Rogers and Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.[13] Permits may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. In Missouri, CAFOs operate under site-specific permits or one of two general permits (MO-G01 or MO-GS1). All CAFO facilities are permitted as no-discharge facilities. The MO-GS1 and site-specific permit for the Missouri Egg Farm facility do not authorize discharges for any reason. The MO-G01 permit, as well

[13] As defined by 10 CSR 20-6.300(1)(B)2, an animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poults in brood phase without a wet handling system.

as the site-specific permit for the Smithfield Hedgewood Farm facility, allow discharge only in the event of weather that exceeds the criteria of a catastrophic storm, and only authorizes discharge of the portion of stormwater flow that exceeds the design storm event, which includes the direct precipitation and runoff from the 25-year, 24-hour storm event. These discharges are not expected to be significant contributors of *E. coli* to surface waters because they are rare and temporary in nature, and may only occur during the defined catastrophic storm events that generally result in high flows that are infrequently met or exceeded.

Thirteen Class IC AFO facilities, two class IA, and two class IB CAFO facilities are present Missouri side of the Thompson watershed.[14] Table 10 lists the CAFO facilities by watershed. Twelve CAFOs operate under a MO-GS1 general permit. Three operate under a general permit and two are site-specific permits. Animal waste applied on areas under the control of a CAFO are subject to conditions found in the permit, which include a requirement for the CAFO to develop a nutrient management plan. Discharge during land application is prohibited. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for surface application of liquefied manure from a CAFO by a third party.[15]

No CAFO in the Thompson River watershed is currently under enforcement. Within the past five years, there have been four instances of non-compliance. In 2018, D and D Buckler Farm was in non-compliance for failing to comply with permit conditions. In 2021, Walnut Grove Pork LTD, failed to provide appropriate permit fees. In 2021, CJ Pork LLC failed to comply with a permit conditions and Trenton Farms RE LLC operated without a permit. Trenton Farms RE LLC is currently operating within a permit. CAFOs violating their permit conditions as they relate to discharge or land application are potential sources of *E. coli* and may be subject to Department enforcement action. When all permit requirements are met, CAFOs are not expected to be contributors through direct discharge of bacteria loading to the Thompson River, Weldon River, and No Creek.[16]

Table 10. CAFOs in Thompson, Weldon, and No Creek watershed

Watershed		Permit Number	Facility Name	Date permit expires	AFO Classification
Thompson	No Creek	MOGS10141	Betz Farms Inc.	1/28/2023	Class IB
	Weldon	MOGS10318	Shield Ag Enterprises, LLC	1/28/2023	Class IC
		MOGS10320	D and D Buckler farm		
		MOG010035	Smithfield Hog Production, Wiles Farm	2/25/2023	
		MO0118753	Smithfield, Hedgewood Farm	9/30/2023	Class IA
		MO0124010	Missouri Egg Farm	12/31/2023	

[14] An operation's "class size" is a category that is based upon the total number of animal units confined at an operation. The Class IC, IB, and IA are categories that start at 1,000, 3,000, and 7,000 animal units respectively, all of which are required by state regulation to obtain a permit. (1,000 animal units is equal to 2,500 swine; 100,000 broilers; 700 dairy cows; or 1,000 beef steers).

[15] Section 640.760 RSMo requires all third party surface applicators of liquefied manure from CAFOs to maintain the following minimum setback distances: 50 feet from a property boundary, 300 feet from any public drinking water lakes, 300 feet from any public drinking water well or intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

[16] Per Missouri Clean Water Law at 644.059 and 644.016(16) RSMo, and Missouri permit regulations at 10 CSR 20-6.300(1)(B)10, discharges of agricultural stormwater are separate from CAFO discharges and are considered nonpoint sources.

		MOG010771	Smithfield, Scott Colby Farm	2/25/2023	Class IB
		MOGS10017	Mike Henke Finisher Facility	1/28/2023	Class IC
		MOGS10019	Mike Henke B and G Facility		
		MOGS10126	Rexing Farms Inc		
		MOGS10151	Brad Vogel Farm		
		MOGS10159	Henke Brothers Hogs		
		MOGS10298	Don Davis		
		MOGS10475	Walnut Grove Pork, LTD		
		MOGS10518	CJ Pork, LLC		
		MOGS10520	Trenton Farms RE, LLC		
		MOG010036	Smithfield, Denver Miller Farm	2/25/2023	

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more. As of 1999, new federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority. As discussed in Section 2.3, at the time of the 2010 census, the U.S. Census Bureau did not designate any areas in the watersheds as urban areas. There are no regulated MS4s in the Thompson, Weldon, and No Creek watersheds. Unregulated runoff from developed areas is discussed in Section 5.2.2.

5.1.5 Other General Permitted Wastewater and Stormwater Discharges

General permits are issued for certain wastewater (MO-G) and stormwater (MO-R) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance, but must also protect water quality. General wastewater and stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 11 lists the effective general and stormwater discharge permits in the Thompson and Weldon watersheds as of August, 24 2020. There are currently no regulated stormwater discharges in the No Creek watershed. Permits associated with construction or land disturbance activities (MO-RA) are temporary. The number of permits of this type may vary in any given year.

Existing and future activities for which general wastewater or stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. Activities conducted in accordance with general wastewater and stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the Department determines that a general permit is not providing adequate water quality protection, the Department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit.

Table 11. General Stormwater Permits in the Thompson, Weldon, and No Creek Watersheds

Watershed	Permit ID	Facility Name	Permit Type	Date the Permit Expires
Thompson	MORA13336	City of Trenton	General Stormwater or Land Disturbance	2/7/2022
	MOR60A043	Frontier Auto and Truck Parts LLC		12/11/2023
	MORA13109	Gilman City		2/7/2022
	MOR60A392	Hobbs Truck and Equipment		12/11/2023
	MOR203086	Modine Manufacturing Company		8/31/2024
	MOR130083	Nestle Professional Trenton MO		9/6/2023
	MORA16176	Orscheln Farm and Home-Trenton, MO		2/7/2022
	MOR80H167	Rapid Removal Transfer Station, LLC		8/31/2024
	MORA17652	Trenton Municipal Airport		2/7/2022
	MOR80F017	Trenton Municipal Airport		11/27/2022
	MORA13376	Trenton Municipal Airport		2/7/2022
	MORA12723	Trenton Municipal Utilities WWTP		2/7/2022
	MOR80C643	Union Pacific Railroad Company - Trenton		11/30/2022
	MOG822264	Yoder Sausage Kitchen		5/22/2022
	MOG490818	Coburn Quarry	Limestone Quarries	4/30/2022
	MOG490663	Edinburg Quarry	Limestone Quarries Petroleum Storage	4/30/2022
	MOG490044	Jeffries Quarry		4/30/2022
	MOG490027	Mercer Quarry		4/30/2022
	MOG491403	Swan Land Improvement of Missouri LLC		4/30/2022
	MOG490010	Trenton Quarry		4/30/2022
	MOG490496	Trenton Ready Mix		4/30/2022
	MOG490547	Trenton Ready Mix North Side		4/30/2022
	MOG490810	Trenton Street Department		4/30/2022
	MOG350295	MFA Oil Bulk Plant Trenton		9/17/2022
	MOG500116	Stoner Sand	Sand/Gravel Washing	5/22/2022
	MOG640200	Trenton Water Treatment Plant	Water Treatment Plant Settling Basins	2/24/2024
	MOG970061	Green Hills Compost, LLC	Yard Waste Composting	8/6/2023

Watershed	Permit ID	Facility Name	Permit Type	Date the Permit Expires
	MORA10456	Princeton Schools	Construction or Land Disturbance	2/7/2022
Weldon and Thompson	MOG822266	Sunrise Meats L.L.C.	Land Application of Food Processing Wastewater	5/22/2022
	MOG490028	Princeton Quarry	Limestone Quarries	4/30/2022
	MOG350228	MFA Oil Bulk Plant Princeton	Petroleum Storage	9/17/2022
	MOG640104	Princeton Water Treatment Plant	Water Treatment Plant Settling Basins	2/24/2024

5.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown and Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Thompson River, Weldon River, and No Creek watersheds. For this reason, it is unknown to what significance straight pipe discharges contribute bacteria loads to surface waters in the watershed. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from Department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Nonpoint sources include agricultural lands, onsite wastewater treatment (septic) systems, and developed areas that do not have regulated storm sewer systems. Agricultural lands associated with land application of wastewater or sludge from permitted facilities, including CAFOs, are also considered nonpoint sources, so long as the activities meet agricultural practices and agronomic land application rates, without direct discharge from land application activities. Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution.

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide manure application and where best management practices are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams will deposit manure, and thus bacteria, directly into the waterway.

As noted in Section 2.4 of this document, the Thompson, Weldon, and No Creek watersheds are dominated by grassland and pasture. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the Thompson, Weldon, and No Creek watersheds are unknown. An estimate of the number of cattle in the Missouri portion of the watershed was calculated by using the available land cover data and county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Using the total number of cattle in Mercer, Grundy, Livingston, Daviess, and Harrison counties and the proportion of each county's area of pastureland in the watershed to the total area of pastureland in each county, it is estimated that there are 76 cows per square mile of grassland or pasture in the Thompson River, Weldon River, and No Creek watersheds (Table 12).[17] This indicates that there are 33,093 cows in the Thompson watershed, 6,590 cows in the Weldon watershed, and 3,535 cows in the No Creek watershed.

Table 12. 2017 Cattle Population Estimates for Pasture Areas in the Missouri side of the Thompson River Watershed

County	Cattle No.	Pastureland (Sq. Mi.)	Pastureland in Watershed (Sq. Mi.)	Pastureland in Watershed/ Total Pastureland	Watershed Cattle No.
Mercer	20,603	219	170.53	0.78	16,013.08
Grundy	20,992	165	137.13	0.83	17,474.01
Livingston	15,064	149	22.22	0.15	2,243.11
Daviess	25,202	227	10.02	0.04	1,114.48
Harrison	43,136	338	95.94	0.28	12,261.10
Total Estimated Cattle in the Thompson River Watershed					33,092.70
Cattle per Square Mile of Pastureland					75.93

Other types of livestock such as horses and sheep may also be contributing bacteria loads in the Thompson River, Weldon River and No Creek. The number and distribution of other animals in the watershed cannot be estimated from available data. Strategies to reduce *E. coli* loading from agricultural areas are outlined in the supplemental Implementation Strategies document located at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

[17] This analysis assumes all areas identified as grassland or pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

5.2.2 Runoff from Developed Areas

As discussed in Section 5.1.4, there are no regulated MS4s in the Thompson, Weldon, and No Creek watersheds. Stormwater runoff from municipal areas may carry high levels of bacteria exceeding water quality criteria during and immediately after storm events (USEPA 1983). *E. coli* contaminated runoff can come from heavily paved areas and areas where soil erosion is common. Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton and Pitt 2002). Irrigation runoff from residential lawns where pet wastes are present may also contribute *E. coli* loads to surface waters.

As presented in Section 2.4, developed areas cover small portions of the total Thompson, Weldon, and No Creek watersheds. Areas categorized as low to high intensity development comprise approximately 2.13 percent of each watershed and areas described as developed open space comprise approximately 4.26 percent of each watershed. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Due to the small amount of developed area in the watersheds, runoff from these areas is not expected to contribute substantial amounts of *E. coli* to the impaired water bodies. If the developed areas are expanded in the future, best management practices and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment (septic) systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface water quality (Horsley and Witten 1996). The Missouri Department of Health and Senior Services or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of septic systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri use onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Thompson, Weldon, and No Creek watersheds is unknown. EPA's online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[18] These STEPL derived estimates of septic system numbers are provided in Table 13. Due to modest increases in the rural population of the watersheds since the 1990 census, this data is assumed to provide a reasonable estimate of actual septic system numbers.

[18] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

Septic systems fail due to age and poor maintenance. Table 13 also provides statewide estimated failure rates from a study by the Electric Power Research Institute (EPRI 2000). The study suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing. Due to these high failure rates, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, aerial imagery indicates that there are few residences in close proximity to Thompson River, Weldon River, and No Creek, so *E. coli* loading to the impaired streams from septic systems is likely minimal.

Table 13. STEPL Derived Estimates of Septic System Numbers

Watershed Name	No. of Systems	Population per System	Average Failure Rate
Thompson	5,376	122	43.15%
Weldon	1,410	28	44.21%
No Creek	267	6	39.00%

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, rodents, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions may be a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for waterfowl, but the Missouri Department of Conservation conducts statewide surveys in fall and winter. In 2020, waterfowl counts ranged from approximately 59,000 in October to 760,000 in late November (MDC 2021a). The exact number of deer in the watershed is also not known, but the Missouri Department of Conservation keeps harvest records by county for each hunting season. Harvest data provides a general idea of the amount of deer that may be present in an area. In the 2020-2021 season, a total of 11,711 deer were harvested in Daviess, Grundy, Harrison, Livingston, and Mercer counties (MDC 2021b). Natural background contributions are included in the nonpoint source load allocations.

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Thompson River, Weldon River, and No Creek watersheds are presented in Tables 14, 15, and 16. Agricultural areas constitute around 34 percent of the riparian corridors of streams in the Thompson and Weldon watershed and about 41 percent of the riparian corridors in the No Creek watershed. These areas may be more susceptible to *E. coli* loading. Over 40 percent of the riparian corridors in the Thompson and Weldon watershed are forested and over 20 percent of the riparian corridors in No Creek watershed are forested. This indicates that some *E. coli* transported from adjacent cropland and pasture lands into those areas may be intercepted before it enters the streams.

Table 14. Land Cover in Riparian Corridors in the Missouri Portion of the Thompson River Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Area Square Miles	Percent
Developed, High Intensity	0.006	0.01%
Developed, Medium Intensity	0.062	0.09%
Developed, Low Intensity	0.422	0.63%
Developed, Open Space	0.868	3.52%
Barren	0.38	0.56%
Cultivated Crops	10.817	16.06%
Hay/Pasture	12.526	18.59%
Shrub/Herbaceous	0.41	0.61%
Forest	28.31	42.02%
Wetlands	9.696	14.39%
Open Water	2.369	3.52%
Totals	67.366	100.00%

Table 15. Land Cover in Riparian Corridors in the No Creek Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Area Square Miles	Percent
Developed, High Intensity	0.000	0.00%
Developed, Medium Intensity	0.003	0.05%
Developed, Low Intensity	0.044	0.74%
Developed, Open Space	0.073	1.23%
Barren	0.000	0.00%
Cultivated Crops	0.785	13.10%
Hay/Pasture	1.650	27.51%
Shrub/Herbaceous	0.011	0.18%
Forest	1.672	27.88%
Wetlands	1.742	29.06%
Open Water	0.016	0.26%
Totals	5.996	100.00%

Table 16. Land Cover in Riparian Corridors in the Missouri Portion of the Weldon River Watershed

Land Type	Riparian Corridor Land Cover Type Area	
	Area Square Miles	Percent
Developed, High Intensity	0.003	0.02%

Developed, Medium Intensity	0.017	0.12%
Developed, Low Intensity	0.09	0.65%
Developed, Open Space	0.181	1.31%
Barren	0.125	0.90%
Cultivated Crops	2.336	16.87%
Hay/Pasture	2.357	17.02%
Shrub/Herbaceous	0.08	0.58%
Forest	6.313	45.59%
Wetlands	1.745	12.60%
Open Water	0.6	4.33%
Totals	13.846	100.00%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (Clean Water Act Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDLs for Thompson River, Weldon River, and No Creek are expressed as *E. coli* cfu per day using load duration curves developed using the *E. coli* criterion concentration target of 206 cfu/100 mL, all possible stream flows, and a unit conversion factor.[19] Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA,* No 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

The selected TMDL target is protective of whole body and secondary contact recreational uses. The resulting load duration curves provide a visual representation of the pollutant loading capacity of the water bodies at all stream flows. The TMDLs are applicable during the recreational season (April-October) when the *E. coli* criterion applies. Using this approach the available loading capacity of the

[19] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{time}}\right) = \boldsymbol{Concentration}\left(\frac{\text{count}}{\text{volume}}\right) * \boldsymbol{Flow}\left(\frac{\text{volume}}{\text{time}}\right) * \boldsymbol{conversion\ factor}$ (24,465,715)

stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, *E. coli* criteria are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curves for Thompson River, Weldon River, and No Creek is provided in Appendix B.

Observed data are plotted on the load duration curve graphs to demonstrate the magnitude of load reductions that are needed to meet the TMDLs and attain water quality standards. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curves also help to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be calculated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Implementation Strategies document located at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

The *E. coli* load duration curves for Thompson River, Weldon River, and No Creek are displayed in Figures 9, 10, and 11. The y-axes quantify the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axes. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The TMDLs and associated allocations at selected percentile flow exceedances are displayed in Tables 17 through 21. The loading capacity for No Creek was calculated using a target concentration of 206 cfu/100 mL. Since Thompson River and Weldon River originate in Iowa their loading capacities were calculated using a target concentration of 126 cfu/100 mL based on the applicable water quality criterion in Iowa for the proportion of flows originating in Iowa, and using the target concentration of 206 cfu/100 mL for the proportion of flows originating in Missouri.[20] Tables 18 and 20 display specific loading capacities and allocations for the Missouri side of the Thompson and Weldon River watersheds. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Specific allocations for individual sources are discussed in Sections 8 and 9.

[20] The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61. In Iowa, the Thompson River's and Weldon River's designated use is class A1 for Primary Contact Recreational Use. For more information on Iowa's designated uses see 567.61.3(1). Under subrule 61.3(3), Class A1 Rivers' *E. coli* concentrations during the recreational season (3/15-11/15) shall not exceed the geometric mean of 126 cfu/100 mL.

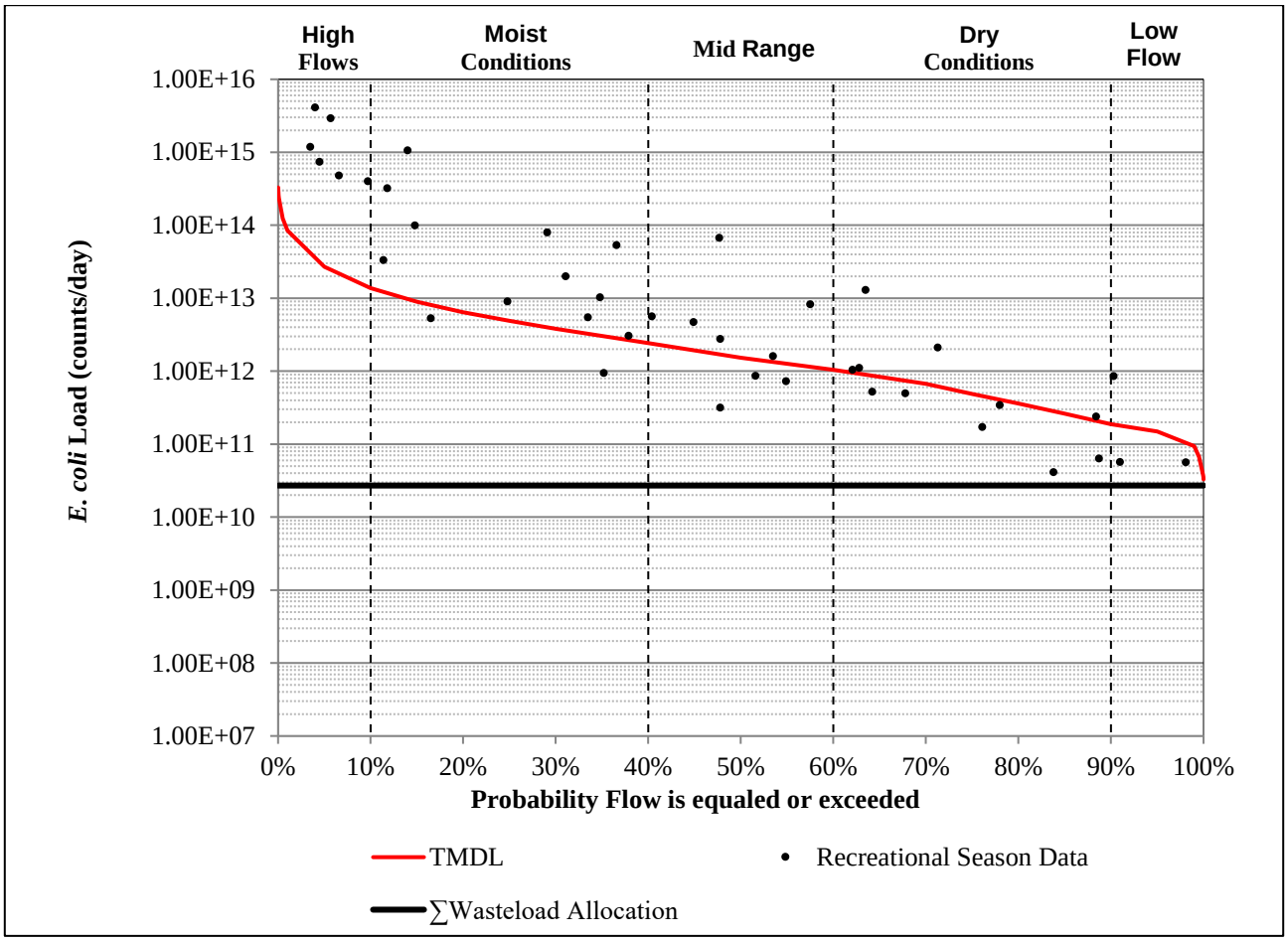

Figure 9. *E. coli* TMDL for Thompson River (WBID 549)

Table 17. *E. coli* TMDL and Allocations for Thompson River at Selected Flows

Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	36.62	1.49E+11	2.71E+10	1.07E+11	1.49E+10
75	120.08	4.88E+11	2.71E+10	4.12E+11	4.88E+10
50	377.78	1.53E+12	2.71E+10	1.35E+12	1.53E+11
25	1,209.15	4.91E+12	2.71E+10	4.39E+12	4.91E+11
5	6,620.77	2.69E+13	2.71E+10	2.42E+13	2.69E+12

Table 18. Missouri Specific *E. coli* TMDL and Allocations for Thompson River at Selected Flows

Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	36.62	9.23E+10	2.71E+10	5.60E+10	9.23E+09
75	120.08	3.03E+11	2.71E+10	2.45E+11	3.03E+10
50	377.78	9.52E+11	2.71E+10	8.30E+11	9.52E+10
25	1,209.15	3.05E+12	2.71E+10	2.72E+12	3.05E+11
5	6,620.77	1.67E+13	2.71E+10	1.50E+13	1.67E+12

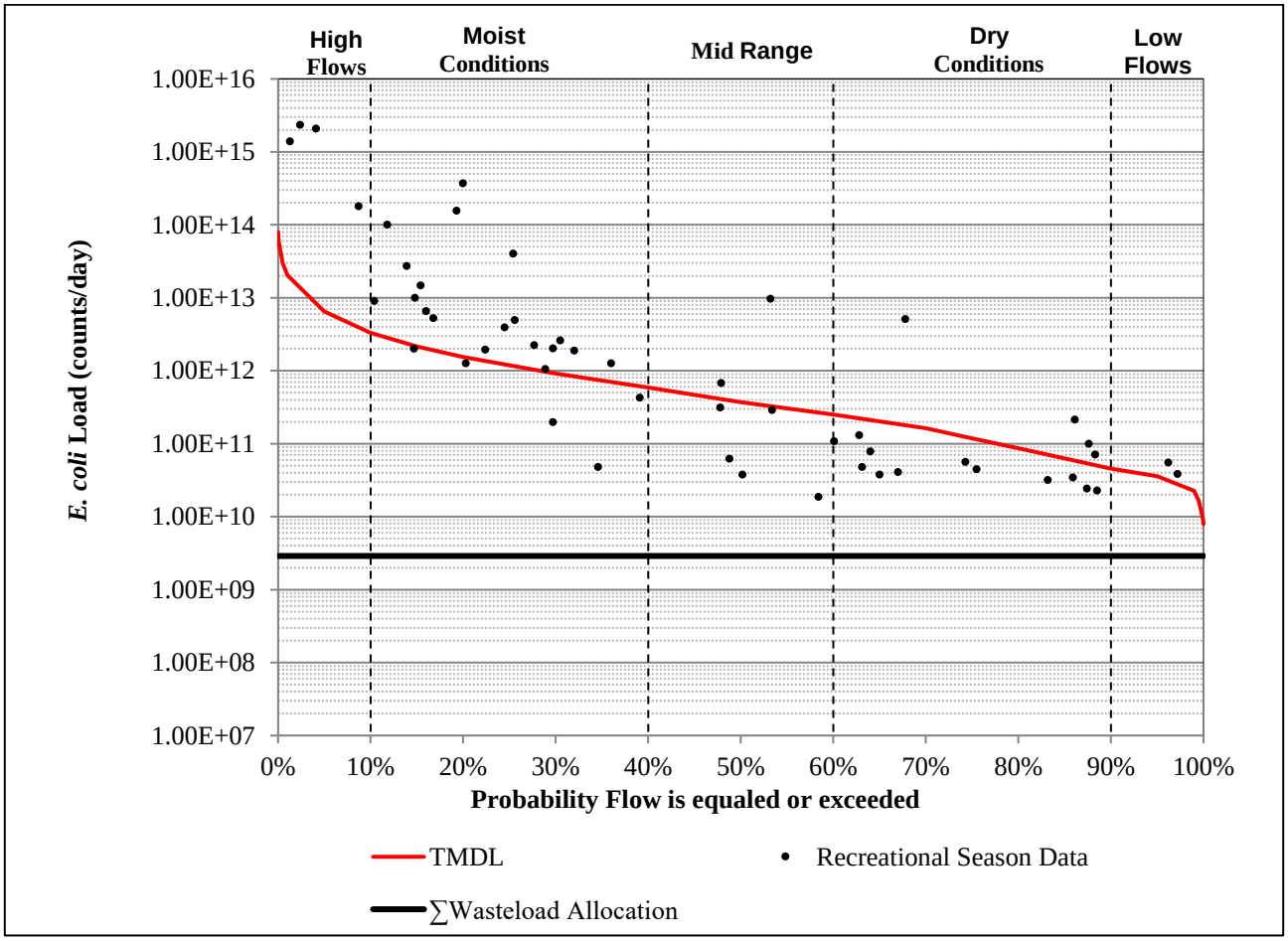

Figure 10. *E. coli* TMDL for Weldon River (WBID 560)

Table 19. *E. coli* TMDL and Allocations for Weldon River at Selected Flows

Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	9.39	3.59E+10	2.89E+09	2.94E+10	3.59E+09
75	30.79	1.18E+11	2.89E+09	1.03E+11	1.18E+10
50	96.86	3.71E+11	2.89E+09	3.31E+11	3.71E+10
25	310.03	1.19E+12	2.89E+09	1.06E+12	1.19E+11
5	1,697.56	6.50E+12	2.89E+09	5.84E+12	6.50E+11

Table 20. Missouri Specific *E. coli* TMDL and Allocations for Weldon River at Selected Flows

Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	9.39	1.80E+10	2.89E+09	1.33E+10	1.80E+09
75	30.79	5.90E+10	2.89E+09	5.02E+10	5.90E+09
50	96.86	1.86E+11	2.89E+09	1.64E+11	1.86E+10
25	310.03	5.94E+11	2.89E+09	5.31E+11	5.94E+10
5	1,697.56	3.25E+12	2.89E+09	2.92E+12	3.25E+11

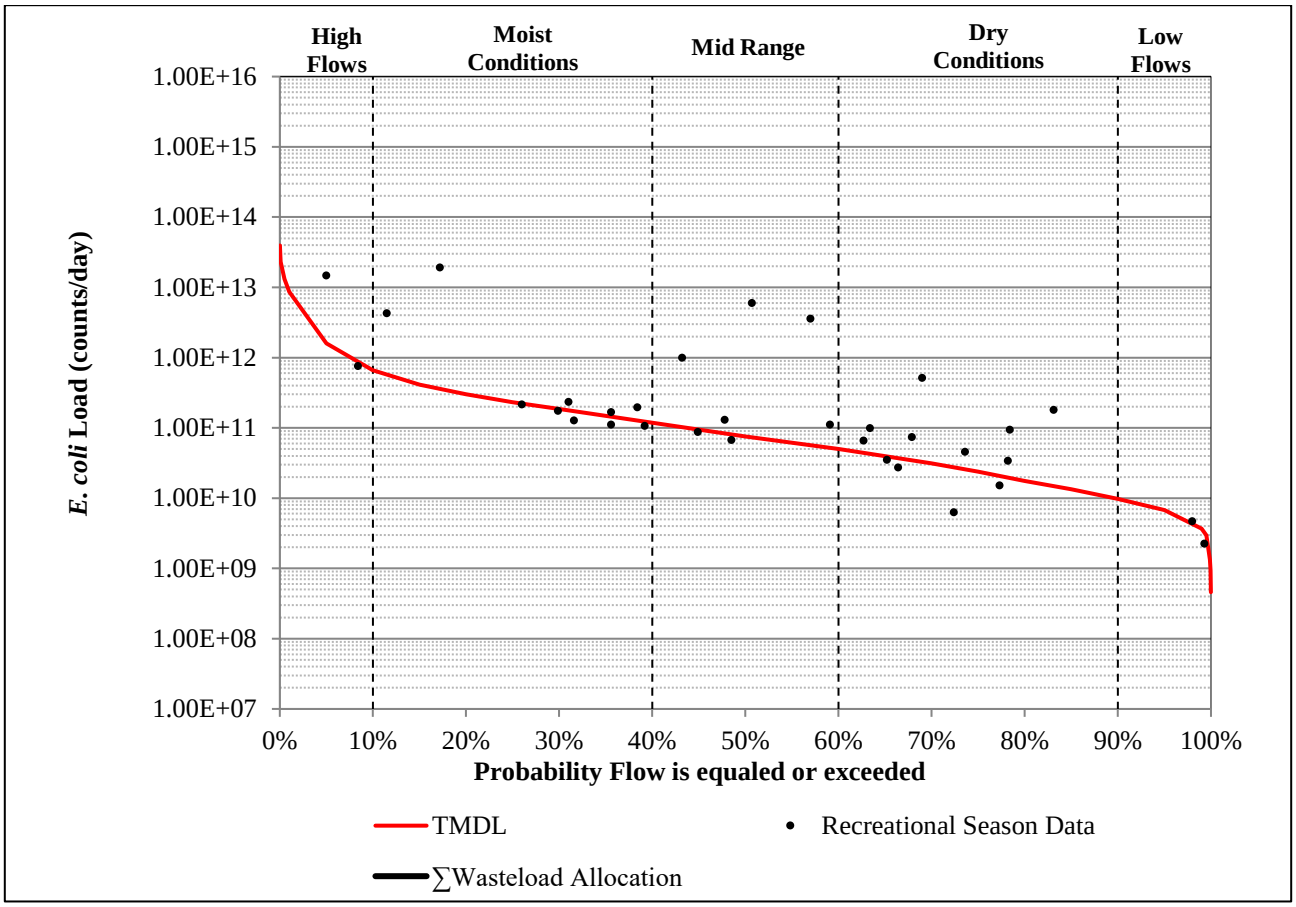

Figure 11. *E. coli* TMDL for No Creek (WBID 550)

Table 21. *E. coli* TMDL and Allocations for No Creek at Selected Flows

Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	1.34	6.77E+09	0.00E+00	6.09E+09	6.77E+08
75	4.70	2.37E+10	0.00E+00	2.13E+10	2.37E+09
50	14.95	7.54E+10	0.00E+00	6.78E+10	7.54E+09
25	45.80	2.31E+11	0.00E+00	2.08E+11	2.31E+10
5	317.00	1.60E+12	0.00E+00	1.44E+12	1.60E+11

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations. Missouri cannot impose TMDL wasteload allocations onto another state, therefore, wasteload allocation targets are calculated only for Missouri permitted facilities. In order to achieve Missouri water quality standards through the loading targets established by this TMDL, it must be assumed that any point source pollutant contributions from Iowa will be limited to ensure Missouri's water quality standards will be met at the state line. The Iowa *E.coli* criterion concentration for both Thompson and Weldon River is 126 cfu/100mL and is more stringent than the Missouri criterion concentration of 206 cfu/100 mL. No portion of the *E. coli* loading capacities for No Creek were allocated to point

sources because the existing point sources either do not discharge wastewater that contains *E. coli* or operate under permits that do not allow discharge to surface waters.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a) disallows the issuance of an the National Pollutant Discharge Elimination System (NPDES) permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* will be required to disinfect its effluent during the recreational season or use other approaches (e.g., no discharge or batch discharges) that will result in negligible bacteria loading during the recreational season and will therefore not cause or contribute to the impairment. Such negligible loading is not expected to and must not exceed the sum of the total wasteload allocation. Decommissioning of onsite wastewater treatment systems and connecting to a sewerage system for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL.

8.1 Domestic Wastewater Treatment Facilities

The aggregated wasteload allocations for domestic wastewater dischargers in the Thompson River watershed is 2.71E+10 *E.coli* cfu/day and is 2.89E+09 in the Weldon River watershed. These allocations are based on individual facility design flows and the *E. coli* criterion concentration of 206 cfu/100 mL (Table 22 and Table 23). The permitted facilities within the Weldon River watershed are also within the Thompson River watershed. These wasteload allocations are equivalent to each other and are not additive. Actual flows that are less than the design flows may result in bacteria loads less than the calculated wasteload allocations. The wasteload allocations in this TMDL report do not authorize any facility to discharge bacteria at concentrations that exceed water quality standards, but may accommodate additional facility loading due to population increases or expansions in service area. The wasteload allocations in this TMDL report are applicable at all flows during the recreational season and do not include loading that may result from sanitary sewer overflows. Sanitary sewer overflows are unpermitted discharges and are not authorized under the Clean Water Act. For this reason, sanitary sewer overflows in the Thompson River watershed, Weldon River watershed, and No Creek watershed are assigned wasteload allocations of zero at all flows.

Table 22. Wasteload Allocations for Domestic Discharges in the Thompson River Watershed

Permit Number	Facility Name	*E. coli* Concentrations (cfu/100 mL)	WLA (cfu/ day)
MO0122467	Cainsville WWTF	206	3.94E+08
MO0056057	Mercer WWTF		3.74E+08
MO0028762	Princeton WWTF		1.49E+09
MO0113026	Spickard WWTF		3.12E+08
MO0039748	Trenton Municipal Utilities WWTP		2.34E+10

MO0129216	Twin Lakes WWTF		1.09E+09
	Total		2.71E+10

Table 23. Wasteload Allocations for Domestic Discharges in the Weldon River Watershed

Permit Number	Facility Name	*E. coli* Concentrations (cfu/100 mL)	WLA (cfu/ day)
MO0028762	Princeton WWTF	206	1.49E+09
MO0113026	Spickard WWTF		3.12E+08
MO0129216	Twin Lakes WWTF		1.09E+09
	Total		2.89E+09

8.2 Industrial and Commercial Facilities

There are currently no site-specific permitted industrial or commercial facilities in the Thompson River, Weldon River, and No Creek watersheds. Princeton Water Treatment Plant, Trenton Water Treatment Plant, Yoder Sausage Kitchen, and Sunrise Meats LLC all hold general permits that do not allow any discharge to surface waters. When all permit limits and conditions are met, these facilities are not expected to cause or contribute to the *E. coli* impairment of Thompson River or Weldon River. For this reason wasteload allocations for the Princeton Water Treatment Plant, Trenton Water Treatment Plant, Yoder Sausage Kitchen, and Sunrise Meats LLC. are set at existing permit limits and conditions. Wasteload allocations for general permitted facilities are further discussed in Section 8.5.

8.3 Concentrated Animal Feeding Operations

All CAFO facilities in the Thompson, Weldon, and No Creek Watersheds are subject to permits that do not allow discharge directly or during land application. For this reason, the *E. coli* wasteload allocations for CAFO facilities is zero at all flows.

8.4 Municipal Separate Storm Sewer Systems

There are no regulated MS4s in the Thompson, Weldon, or No Creek watersheds. *E. coli* in stormwater runoff from developed areas are included in the load allocation for nonpoint sources. If MS4 permits are required for stormwater discharges from urban areas in the future, then the appropriate proportion of the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation.

8.5 Other General Permitted Wastewater and Stormwater Discharges

Activities that require general or stormwater permits are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watersheds. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For these reasons, the *E. coli* wasteload allocations for these facilities are set at existing permit limits and conditions. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above negligible levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are assigned *E. coli* wasteload allocations of zero. Any existing illicit straight pipe discharges must be eliminated and future discharges of this type should be prevented.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). The load allocation for Thompson River and Weldon River TMDL is calculated as the remainder of the loading capacity after allocations to the wasteload allocation and the margin of safety. Because the wasteload allocations for all point sources are zero, in the No Creek TMDL, the *E. coli* load allocations are equal to the loading capacity minus the margin of safety as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocations is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed they do not discharge *E. coli* directly to surface waters. For the Thompson River TMDL and Weldon River TMDL, the load allocations also include any point source and nonpoint source contributions originating from Iowa. It is assumed that point source contributions from Iowa will be limited to ensure Missouri water quality standards are met at the state line.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

An explicit margin of safety equal to 10 percent of the loading capacity is included in the TMDLs. Additionally, bacteria decay rates were not applied and the direct recreational-season geometric mean was used for estimating the daily loading value as required by the federal Clean Water Act. These conservative assumptions serve as an additional implicit margin of safety.

12. Monitoring Plans

The Department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit compliance schedules, or the implementation of watershed BMPs. The Department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curves provide the *E. coli* loading capacities for each water body at all possible flow regimes using data collected during all seasons. The *E. coli* TMDLs are therefore protective of designated uses throughout the recreational season, including during high flows associated with intense rainfall events when bacteria loading is more likely (the critical condition).

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through NPDES permitting program. State operating permits requiring effluent and instream monitoring be reported to the Department provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or best management practices within the watershed. If best management practices or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or best management practices are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the Thompson River, Weldon River, and No Creek watersheds are provided in the supplemental TMDL Implementation Strategies document available online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

14. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. A 45-day public notice period for this TMDL report was scheduled from March 4, 2022 through April 18, 2022. Groups that directly received notice of the public comment period for this TMDL include, but are not limited to:

- Missouri Clean Water Commission;
- Missouri Department of Conservation;
- Harrison, Mercer, Grundy, Daviess, and Livingston County Soil and Water Conservation Districts;
- County health departments;
- County commissions;
- University of Missouri Extension;
- Missouri Coalition for the Environment;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups directly contacted about the public notice, this TMDL report and an implementation strategies document are posted on the Department's TMDL webpage dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. All comments received during this period and the Department's responses to those comments are also available at this location.

The Department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The Department has an administrative record on file for the Thompson River, Weldon River, and No Creek *E. coli* TMDL. The record contains any plans, studies, data, and calculations on which the TMDL is based. It additionally includes the TMDL implementation strategies document, the public notice announcement, any public comments received, and the Department's responses to those comments. This information is available upon request to the Department at dnr.mo.gov/sunshinerequests.htm. The Department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMo) and the Department's administrative policies and procedures governing Sunshine Law requests.

16. References

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Appendix A

Thompson River, Weldon River, and No Creek (WBIDs 549, 560, 550) *E. coli* data collected by the U.S. Geological Survey (USGS) and the Iowa Department of Natural Resources (IDNR)

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
549	IDNR	549/70.6/5.7	Thompson Fork - Grand River at Davis City	4/6/2015	264102	10.0
				5/4/2015	264103	150.0
				6/1/2015	264104	1000.0
				7/6/2015	264105	84.0
				8/3/2015	264106	20000.0
				9/3/2015	264107	630.0
				10/5/2015	264108	390.0
				4/4/2016	264114	52.0
				5/9/2016	264115	300.0
				6/6/2016	264116	3100.0
				7/5/2016	264117	180.0
				8/1/2016	264118	6500.0
				9/6/2016	264119	280.0
				10/3/2016	264120	400.0
				4/10/2017	293428	460.0
				5/1/2017	293429	20000.0
				6/12/2017	293430	200.0
				7/3/2017	293431	390.0
				8/7/2017	293432	140.0
				9/6/2017	293433	52.0
				10/2/2017	293435	52.0
				4/9/2018	293441	31.0
				5/1/2018	293442	63.0
				6/5/2018	293444	3300.0
				7/5/2018	293445	910.0
				8/6/2018	293446	86.0
				9/5/2018	293447	4100.0
				10/1/2018	293448	190.0
	USGS	549/49.6	Thompson River near Moriah	5/5/2015	255709	19000.0
				7/8/2015	255711	4200.0
				9/16/2015	255713	340.0
				10/28/2015	255717	370.0
				5/5/2016	278344	1800.0
				7/8/2016	278345	2400.0
				9/14/2016	278346	3800.0
				10/5/2016	278347	270.0
				5/11/2017	276215	4600.0
				7/20/2017	276216	110.0
				9/20/2017	276217	190.0
				10/19/2017	276218	1200.0
				5/10/2018	277288	560.0
				7/11/2018	277289	200.0
				9/7/2018	277290	5000.0
				10/4/2018	277291	760.0

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
				4/4/2019	301438	110.0
				5/8/2019	301439	4700.0
				7/18/2019	301440	100.0
				9/6/2019	301441	100.0
				10/3/2019	301442	20000.0
				6/11/2020	302139	18000.0
				7/14/2020	302140	96.0
				9/15/2020	302141	560.0
				10/15/2020	302142	23.0
550		550/17.7	No Creek near Dunlap	4/27/1998	52653	130.0
				6/2/1998	52654	2050.0
				8/24/1998	52655	740.0
				4/22/1999	52658	700.0
				6/21/1999	52659	2500.0
				10/25/1999	52660	970.0
				4/20/2000	52665	6000.0
				5/9/2000	52666	88000.0
				6/14/2000	52667	8000.0
				6/22/2000	52668	610.0
				7/25/2000	52669	1600.0
				10/24/2000	52670	8500.0
				4/24/2001	52676	1200.0
				5/22/2001	52677	8.0
				6/19/2001	52678	6600.0
				6/25/2001	52679	240.0
				7/26/2001	52680	4200.0
				8/9/2001	52681	390.0
				9/13/2001	52682	170.0
				10/23/2001	52683	37000.0
				4/18/2002	52688	93.0
				5/23/2002	52689	160.0
				6/13/2002	52690	670.0
				6/28/2002	52691	510.0
				7/23/2002	52692	380.0
				8/22/2002	52693	15000.0
				4/25/2003	52697	1900.0
				4/30/2003	52698	680.0
				5/6/2003	52699	4700.0
				6/12/2003	52700	1100.0
				7/9/2003	52701	1600.0
				9/19/2003	52702	6200.0
				10/23/2003	52703	750.0
				4/20/2004	52709	2000.0
				5/11/2004	52710	130.0
				6/22/2004	52711	500.0
				7/16/2004	52712	2300.0
				8/23/2004	52713	7800.0

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
				9/14/2004	52714	14000.0
				10/26/2004	52715	3500.0
				4/5/2005	52721	62.0
				5/12/2005	52722	2100.0
				6/30/2005	52723	4600.0
				7/13/2005	52724	400.0
				8/19/2005	52725	1400.0
				9/21/2005	52726	200.0
				10/5/2005	52727	12000.0
				4/12/2006	52733	260.0
				5/9/2006	52734	240.0
				6/15/2006	52735	1100.0
				7/19/2006	52736	8400.0
				8/10/2006	52737	1100.0
				9/21/2006	52738	5600.0
				4/27/2007	52744	10000.0
				5/10/2007	52745	770.0
				6/28/2007	52746	40000.0
				7/19/2007	52747	520.0
				8/23/2007	52748	6800.0
				9/16/2007	52749	310.0
				9/27/2007	52750	1100.0
				10/8/2007	52751	48.0
				4/16/2008	52756	260.0
				5/22/2008	52757	3400.0
				6/17/2008	52758	1200.0
				7/15/2008	52759	920.0
				8/12/2008	52760	480.0
				9/23/2008	52761	470.0
				4/24/2009	200543	160.0
				5/15/2009	200544	6800.0
				6/23/2009	200545	1700.0
				7/24/2009	200546	590.0
				8/18/2009	200547	3200.0
				9/15/2009	200548	2200.0
				10/6/2009	200549	2500.0
				4/23/2010	200555	6400.0
				5/18/2010	200556	2000.0
				6/15/2010	200557	12000.0
				7/27/2010	200558	480.0
				8/17/2010	200559	150.0
				9/21/2010	200560	3000.0
				10/5/2010	200561	140.0
				4/5/2011	212028	210.0
				5/3/2011	212029	160.0
				6/7/2011	212030	230.0
				7/12/2011	212031	690.0

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
				8/16/2011	212032	23000.0
				9/13/2011	212033	100.0
				10/5/2011	212034	1700.0
				4/17/2012	222927	380.0
				5/23/2012	222928	68.0
				6/5/2012	222929	240.0
				4/11/2013	238584	6200.0
				5/23/2013	238585	880.0
				6/24/2013	238586	1500.0
				7/8/2013	238587	130.0
				8/12/2013	238588	89.0
				9/17/2013	238589	3200.0
				4/7/2014	243939	6.0
				5/5/2014	243940	150.0
				6/9/2014	243941	1100.0
				7/15/2014	243942	490.0
				8/18/2014	250937	290.0
				9/22/2014	250938	220.0
				10/6/2014	250939	160.0
				4/14/2015	255730	220.0
				5/11/2015	255734	23000.0
				6/15/2015	255738	8800.0
				7/30/2015	255741	6500.0
				8/10/2015	255744	2500.0
				9/3/2015	255748	590.0
				10/5/2015	255751	660.0
				4/7/2016	278351	200.0
				5/19/2016	278352	190.0
				6/21/2016	278353	11000.0
				7/19/2016	278354	270.0
				8/25/2016	278355	17000.0
				9/22/2016	278356	240.0
				10/17/2016	278357	180.0
				4/11/2017	276222	1600.0
				5/18/2017	276223	320.0
				6/8/2017	276224	150.0
				7/11/2017	276225	440.0
				8/8/2017	276226	1000.0
				9/26/2017	276227	2500.0
				10/5/2017	276228	360.0
				4/13/2018	277295	46.0
				5/15/2018	277296	13000.0
				6/4/2018	277297	320.0
				7/25/2018	293070	140.0
				8/22/2018	277298	210.0
				9/18/2018	277299	360.0
				10/22/2018	277300	190.0

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
				4/11/2019	301446	150.0
				6/5/2019	301447	190.0
				7/9/2019	301448	170.0
				7/22/2019	301449	2000.0
				8/16/2019	301450	470.0
				9/17/2019	301451	150.0
				10/24/2019	301452	160.0
				6/8/2020	302146	180.0
				6/23/2020	302147	1900.0
				8/31/2020	302149	3200.0
				9/29/2020	302150	300.0
				10/20/2020	302151	440.0
560		560/29.0	Weldon R. near Princeton	5/16/2000	52766	200.0
				7/11/2000	52767	3.0
				9/6/2000	52768	1.0
				5/2/2001	52772	8100.0
				7/11/2001	52773	15.0
				9/18/2001	52774	620.0
				5/7/2002	52778	19000.0
				7/30/2002	52779	150.0
				8/15/2002	52780	160.0
				9/5/2002	52781	9.0
				10/24/2002	52782	330.0
				5/20/2003	52788	2975.0
				7/17/2003	52789	55.0
				9/5/2003	52790	190.0
				5/18/2004	52794	32000.0
				7/7/2004	52795	110.0
				9/8/2004	52796	810.0
				5/23/2005	52800	7000.0
				7/6/2005	52801	200.0
				9/14/2005	52802	100.0
				5/23/2006	52806	16.0
				7/25/2006	52807	190.0
				9/6/2006	52808	5.0
				4/6/2007	52814	280.0
				5/23/2007	52815	10.0
				6/20/2007	52816	260.0
				7/25/2007	52817	70.0
				9/19/2007	52818	67.0
				5/29/2008	52823	670.0
				7/10/2008	52824	7200.0
				9/17/2008	52825	1100.0
				5/7/2009	200578	430.0
				7/16/2009	200579	170.0
				9/3/2009	200580	500.0
				10/21/2009	200581	34.0

Water Body	Organization	Site Code	Site Name	Date	Sample ID	*E.coli* (#/100ml)
				5/6/2010	200584	220.0
				7/15/2010	200585	130.0
				9/15/2010	200586	15000.0
				10/21/2010	200587	11.0
				5/25/2011	212045	30000.0
				7/18/2011	212046	25.0
				9/28/2011	212047	62.0
				10/19/2011	212048	67.0
				5/2/2012	222936	1800.0
				7/19/2012	222937	92.0
				9/20/2012	231775	200.0
				10/17/2012	238602	220.0
				5/9/2013	238605	510.0
				7/17/2013	238606	58.0
				9/24/2013	238607	72.0
				9/25/2013	238608	72.0
				10/23/2013	238609	260.0
				5/20/2014	243945	340.0
				7/9/2014	243946	5600.0
				9/4/2014	250949	440.0
				10/22/2014	250950	340.0
				5/6/2015	255775	37000.0
				7/8/2015	255777	5400.0
				9/16/2015	255779	110.0
				10/28/2015	255783	4600.0
				5/5/2016	278368	700.0
				7/7/2016	278369	4400.0
				9/13/2016	278370	350.0
				10/5/2016	278371	120.0
				5/10/2017	276238	450.0
				7/19/2017	276239	29.0
				9/21/2017	276240	300.0
				10/18/2017	276241	140.0
				5/9/2018	277309	33.0
				7/11/2018	277310	92.0
				9/6/2018	277311	12000.0
				10/3/2018	277312	580.0
				4/3/2019	301462	140.0
				5/9/2019	301463	40000.0
				7/17/2019	301464	16.0
				9/5/2019	301465	34.0
				10/10/2019	301466	50000.0
				6/11/2020	302157	32000.0
				7/14/2020	302158	60.0
				9/15/2020	302159	160.0
				10/15/2020	302160	140.0

Appendix B

Development of *E. coli* Load Duration Curves

Overview

Load duration curves were used to develop the *E. coli* TMDLs for Thompson River, Weldon River, and No Creek. Load duration curves visually display the loading capacity of a water body at all possible flows based on historic flow data and the defined target concentration for each pollutant. For this TMDL, a portion of the *E. coli* loading capacity is assigned to a wasteload allocation based on the individual design flows of domestic wastewater treatment facilities present in the watershed. Ten percent of the loading capacity is reserved as an explicit margin of safety. The remaining portion of the loading capacity is allocated to nonpoint sources.

Methodology

Load duration curves are based on a flow duration curve developed using a long-term time series of daily average flows and a numeric water quality target. The numeric target for the *E. coli* load duration curves is the whole body contact category B criterion of 206 cfu/100 mL.

Load duration curves are based on a flow duration curves developed using a long-term time series of daily flows and a numeric water quality target. Average daily flow data that are representative of the impaired segment are used to develop the flow duration curve. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same ecological drainage unit.

For Thompson River and Weldon River, flow estimates were area-corrected based on flows measured at USGS stream gage 06899500, located on Thompson River near Trenton, Missouri from July 2001 to July 2021. For No Creek, flow estimates were area-corrected based on flows measured at USGS stream gage 06900050, located on Medicine Creek near Lareado, MO from July 2001 and July 2021. Average daily flows were corrected based on the proportion of the area draining to the impaired water body segment. For Weldon and Thompson River, in addition to calculating the total daily flow of each impaired segment, the daily flow was calculated for each state using correction factors based on the proportion of the drainage area for Missouri and Iowa (Table B-1). For No Creek, flow estimates were area-corrected based on flows measured at USGS stream gage 06900050, located on Medicine Creek near Lareado, MO. Figures B-1, B-2, and B-3 present the flow duration curve developed for the impaired segments.

Because the Thompson River watershed and Weldon River watershed are located within two states, the loading capacity was derived with considerations to both Missouri and Iowa water quality standards. The loading capacity specific to the portion of the Thompson and Weldon River located in Missouri was calculated based on the whole body contact category B *E. coli* criterion concentration of 206 cfu/100 mL, daily flows proportional to the Missouri portion of the watershed, and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day.[21] The proportion of the total loading capacity originating from Iowa was calculated based on Iowa's A1 criterion concentration of 126 cfu/100 mL, daily flows proportional to the Iowa portion of the

[21] $Load\ \left(\frac{\text{count}}{\text{day}}\right) = \left[Target\left(\frac{\text{count}}{100\text{ml}}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right) * MO\ proportion\ of\ watershed\ area\right] * [Conversion\ Factor]$

watershed, and the previously stated conversion factor. The total loading capacity for the Thompson and Weldon River is the sum of allowable loading in Missouri and Iowa.[22]

Table B-1. Information used for developing area corrected flow records[23]

Watershed	Drainage Area (mi^2)	Conversion Factor
USGS 06899500 Thompson River near Trenton, MO	1,720	-
Thompson River (Total Watershed)	2,210	1.28
Missouri Portion of the Thompson River Watershed	1,106	0.643
Iowa Portion of the Thompson River Watershed	1,104	0.642
Weldon River (Total Watershed)	567	0.329
Missouri Portion of the Weldon River Watershed	216	0.098
Iowa Portion of the Weldon River Watershed	351	0.159
USGS 06900050 Medicine Creek near Laredo, MO	355	-
No Creek	111	0.312

[22] $Load\ \left(\frac{\text{count}}{\text{day}}\right) = \left[\left[Iowa\ Target\left(\frac{\text{count}}{\text{100ml}}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right)\right] * [Iowa\ Conversion\ Factor]\right] + [\left[Missouri\ Target\left(\frac{count}{100ml}\right)\right] * \left[Flow\ \left(\frac{feet^3}{s}\right)\right] * [Iowa\ Conversion\ Factor]]$

[23] Flow data that were in provisional status at the time of this report were not used.

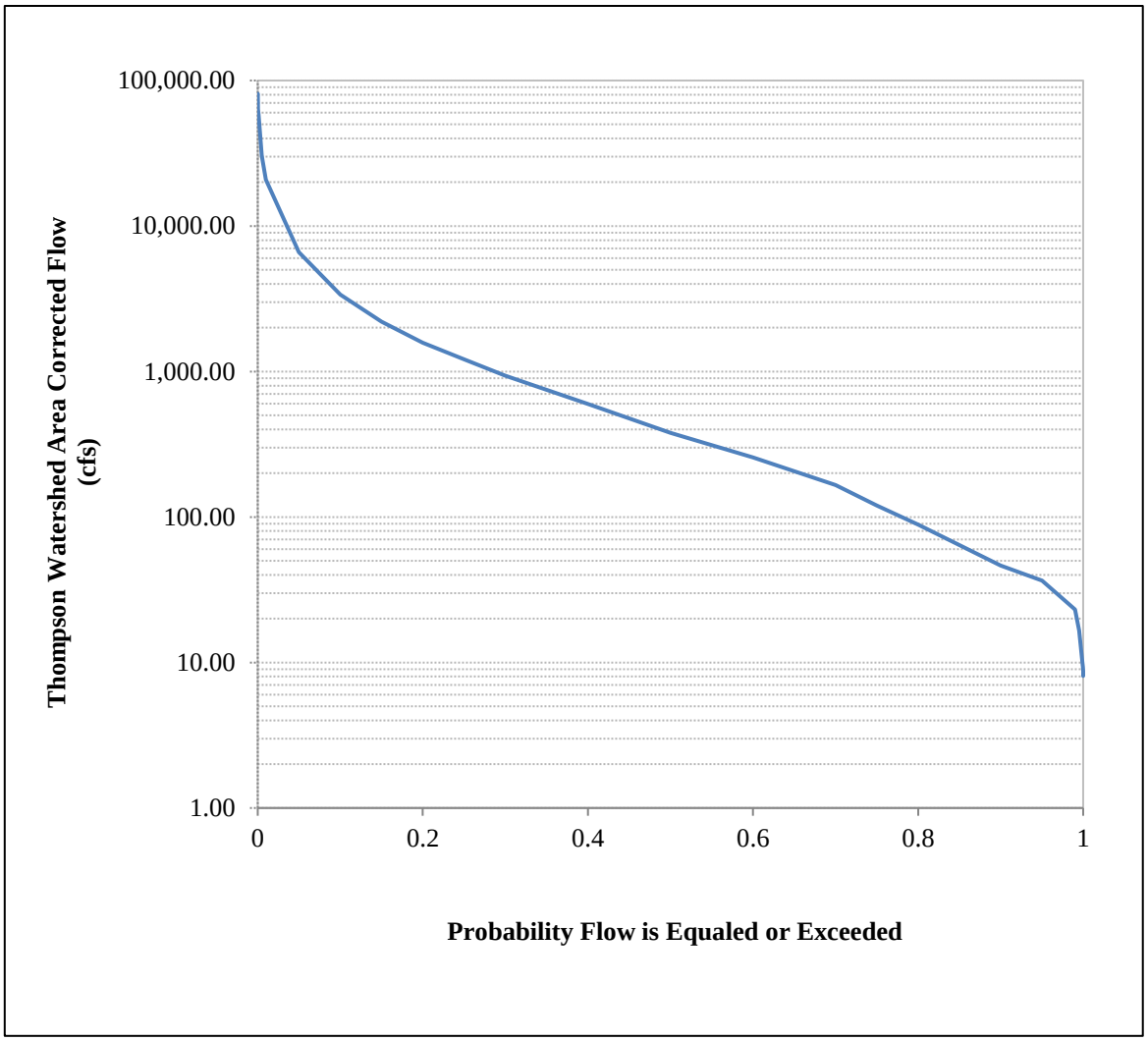

Figure B-1. Thompson River Flow Duration Curve

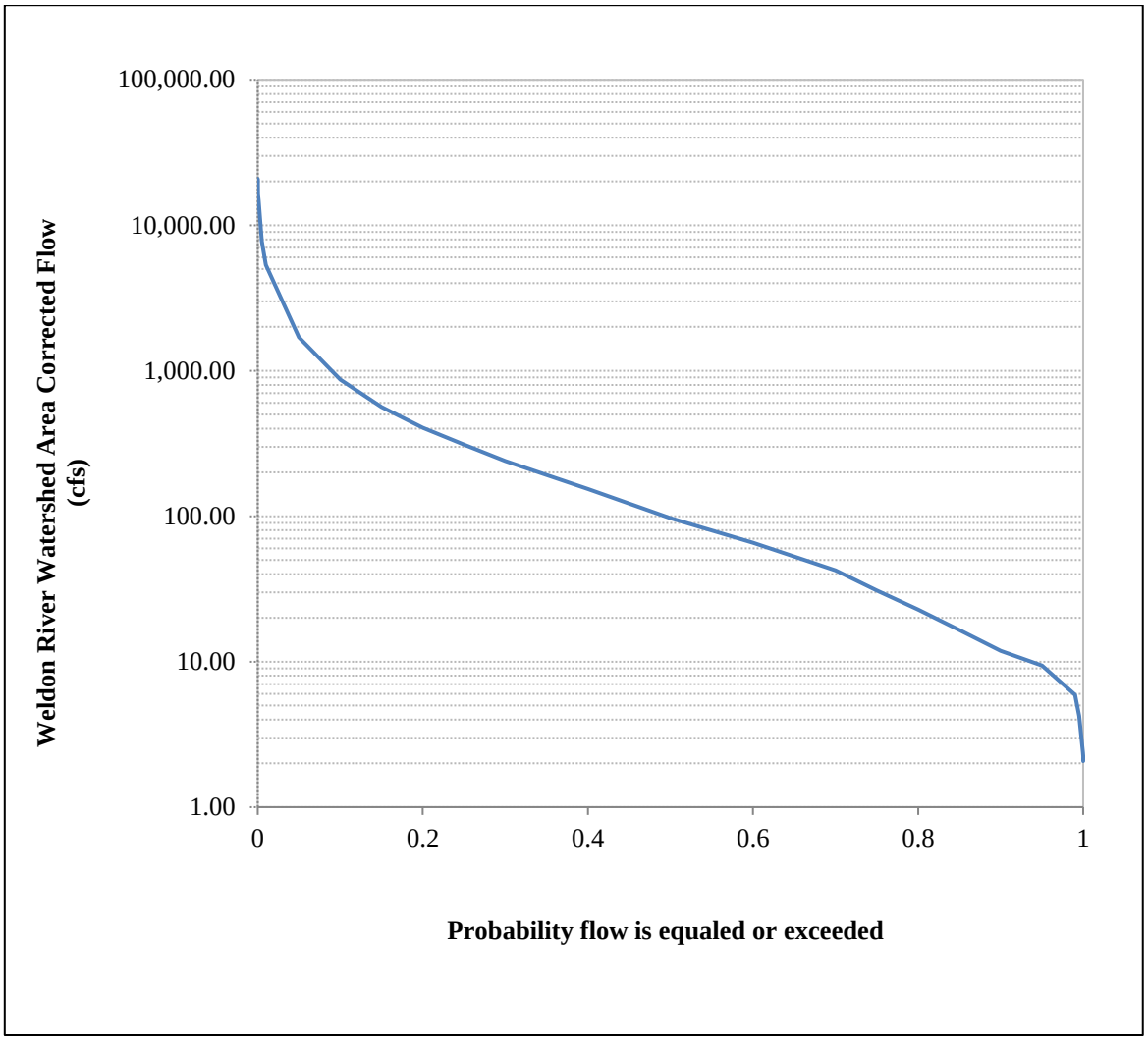

Figure B-2. Weldon River Flow Duration Curve

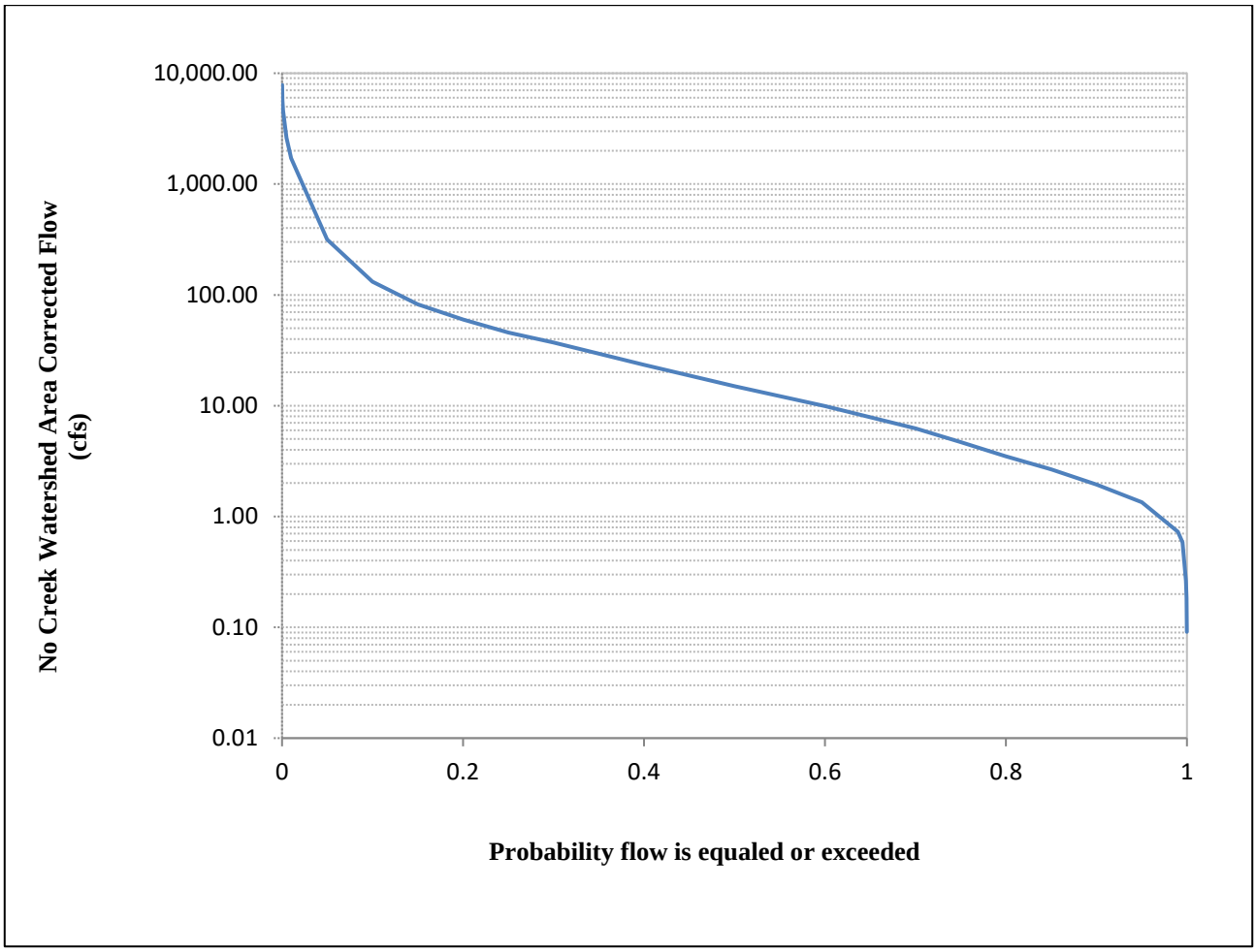

Figure B-3. No Creek Flow Duration Curve